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A Demonstration of Practical Forestry in Northern Minnesota

T. S. Hansen, J. H. Allison, R. M. Brown,
E. G. Cheyney, and Henry Schmitz
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THE CLOQUET FOREST

A DEMONSTRATION OF PRACTICAL FORESTRY IN NORTHERN MINNESOTA

T. S. HANSEN, J. H. ALLISON, R. M. BROWN,
E. G. CHEYNEY, AND HENRY SCHMITZ

INTRODUCTION

In northern Minnesota there are about twenty million acres of forest land, most of which have been cut and burned over. Forest growth of one kind or another has re-established itself on 15,000,000 acres, but 5,000,000 acres are still essentially unproductive.

For many years it was hoped, if not actually believed, that agriculture would utilize a large portion of this "cut-over" land. This, however, it has failed to do, in spite of the fact that ten million acres, at least, are possible crop land not requiring drainage. Since 1920 the population of this part of the state has been stationary.

That agriculture will not and can not utilize more than a small part of the total land available, is becoming increasingly apparent. Settlement has been slow and expensive in both material and human labor. The high cost of public improvements for scattered settlements has placed an almost intolerable burden on property owners. As a consequence, approximately 7,000,000 acres are now tax delinquent.

The economic problems of the cut-over area are constantly becoming more acute. Planned settlement and the zoning of what is, both physically and economically, admittedly forest land will go far toward alleviating future difficulties, but they will not entirely solve the problem. If possible, both public and private land not required for agriculture should be made productive. The production of timber crops on lands suited to that purpose, and the secondary benefits resulting therefrom, will go far toward rehabilitating the economic and social integrity of the region.

Public forestry in America is an established fact. Private forestry, on the other hand, has made comparatively little progress. To be sure, a few large private owners of timber lands have followed practices which, if continued, may result in continuous forest production; but this condition is an exception rather than a rule. The total area of privately owned timber land managed on a sustained yield basis is insignificant.

This condition is not necessarily the fault of the private owners of forest land. Many such owners have for years seriously considered the

possibilities and limitations of forest management, but basic information concerning the possibility of timber growing has been lacking. The private owner, with annual taxes, fixed charges, and protection costs to pay, finds little comfort or help in the generalizations of sustained yield enthusiasts. Facts concerning the financial returns from timber growing are sorely needed.

The Cloquet Forest is an example of what may be expected of a forest property in northern Minnesota. To be sure, taxes, overhead and other fixed charges of private enterprises are not considered in the following statement of the results of more than twenty years of forest management on the Cloquet Forest. Nevertheless, the Cloquet forest area as a whole is fairly representative of much of the forest land in northern Minnesota, both in regard to soil productvity and the condition of the forest at the time management began. Consequently the private owner of timber land may study the yields here reported with the expectation that he may do as well or better, and he may add the taxes, overhead and any other fixed charges applicable to his particular property, and study the net financial result, or at least balance yield against costs.

LOCATION, AREA, AND STATUS OF THE CLOQUET FOREST

The Cloquet Forest, consisting of 2,953.3 acres, is located in the northeastern part of Carlton County, Minnesota. It lies 4 miles southwest of the city of Cloquet and 24 miles west of the city of Duluth.

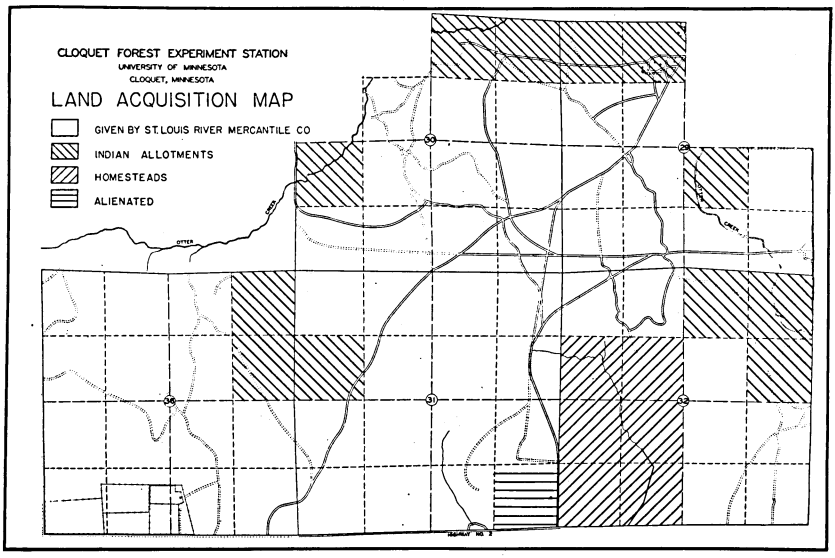

Figure 1

The forest lies in five sections located in two townships. It includes Section 36, T 49N, R 18W; all except the SE¼ of SE¼ of Section 31; all of Section 32; all except the NE¼ of Section 29, and all except three forties in the NW¼ of Section 30, T 49N, R 17W, as shown on map, Figure 1.

The boundaries of the forest have been surveyed, and are well marked; old State T.H. No. 2 forms the southern boundary and Otter Creek in general parallels the northern boundary. Township roads bound the forest on the east and west. The interior 40 lines of the forest have been surveyed and swamped out to facilitate administration and protection.

HISTORY

The Cloquet Forest was originally part of the Fond du Lac Indian Reservation. In 1907, the Government allotted a part of this reservation to members of the tribe and opened the remainder for settlement by homesteaders, the establishment of timber and stone claims, etc.

Just at this time Minnesota was fortunate in having Prof. Samuel B. Green, a man of unusual vision and foresight, at the head of the Minnesota Forest School. As early as 1896 he had advocated the acquisition of a demonstration forest by the University. In the opening of a part of the Fond du Lac Reservation, he saw an opportunity to obtain such an area. After two years of persistent effort, he succeeded in persuading the St. Louis River Mercantile Company to purchase 2,215 acres of land for the University. This land, with the exception of 80 acres, owned by the Northern Lumber Company, was unallotted Indian land not yet taken up as homesteads. A special act of congress was required to permit this purchase. The land was deeded directly to the University by the Federal Government upon the payment by the St. Louis River Mercantile Company of $1.25 per acre to the tribal funds. In order to round out the boundaries and make the tract a more convenient and sizeable unit for forestry practice, the University secured congressional authority to purchase eight Indian allotments, aggregating 447 acres, within the boundaries of, or adjoining, the 2,215 acres donated to the University by the St. Louis River Mercantile Company. These tracts were finally purchased in 1910 by the University for $4,952, or an average cost of $11.08 per acre.

Logging of the tract had already begun when the land was given to the University, but Professor Green asked the companies to leave standing certain seed trees and groups of mature white and Norway pine for experimental purposes. In compliance with this request, the lumber company left 109,000 board feet of white pine and 1,188,000 feet of Norway pine. For the timber thus left the University paid the North-

ern Lumber Company $8,574.34, the same price that the company had paid the government for it ten years earlier. Thus the Cloquet Forest is in no small measure the result of the interest and generosity of the St. Louis River Mercantile Company and the Northern Lumber Company.

Two homesteads had been established within the boundaries of the tract and a third lay partly within the boundaries. It was, however, impossible to secure any of these tracts until after the entrymen had secured title to the land, and not until 1925 were funds available for their purchase. By that time all the merchantable timber had been removed from the two homesteads within the forest boundaries. One 120-acre tract was purchased for $1,000; the other for $2,300. One 40-acre tract of the third homestead, on which the timber has not yet been cut, still remains within the boundaries of the forest as the property of the original entryman. It is hoped that the University will some time be able to acquire this tract. The total already acquired from all sources is 2,953.3 acres.

Figure 1 shows the location of the various purchase units in the Cloquet Forest.

Past logging treatment.—Prior to the establishment of the Cloquet Forest in 1910, the logging on the area was supervised by the Indian Service. Norway and white pine were cut clear, and the slash was piled and burned as logging progressed. Stumps were cut much lower than was common practice at that time, and in general the area was left in better condition than most cut-over areas outside the reservation.

The merchantable material on the two homesteads purchased in 1925 was cut clear in 1912 and the slash left on the ground. The slash for a time remained a hazard, but fortunately this area never burned.

Since the establishment of the forest, logging has been carried on either by the forest crew or by contractors under the supervision of the forest manager. As occasion has demanded, both clear and partial cutting have been practiced. In most instances slash was burned as logging progressed; on one or two cutting areas the slash was lopped and scattered.

PHYSIOGRAPHIC FEATURES

Topography.—The forest is located in the region of the young, red drift left by the Superior ice lobe. The immediate area is classed as an outwash gravel plain, altho there are some evidences of morainic formation. The topography is rolling; practically no level terrain is found except the swamps. Elevation varies between 1,230 feet and 1,290 feet above sea level. The forest consists of 1,919.3 acres of upland and 1,034.0 acres of swamp.

Nowhere on the tract is the topography sufficiently rough to make

logging difficult. Common sense and good judgment in the location of temporary winter logging roads is all that is necessary.

The forest lies in the drainage basin of the St. Louis River. Otter Creek, a tributary of the St. Louis River, roughly bounds the forest on almost three sides. It flows northeast across the northwest corner, in and out across the north boundary, and down the east boundary for a mile and a quarter. It drains the entire tract, and serves as more or less of a firebreak around the whole of the north half.

Soils.—The U. S. Bureau of Soils classified the soils in 1905 as Miami sand and Miami sandy loam. In 1934 the major soils of the forest were classed by the Soils Division of the University of Minnesota as Omega sand and Cloquet and Munger fine sandy loam. Figure 2 shows the location of the swamps, as well as the various classes of soils distinguished in this study.

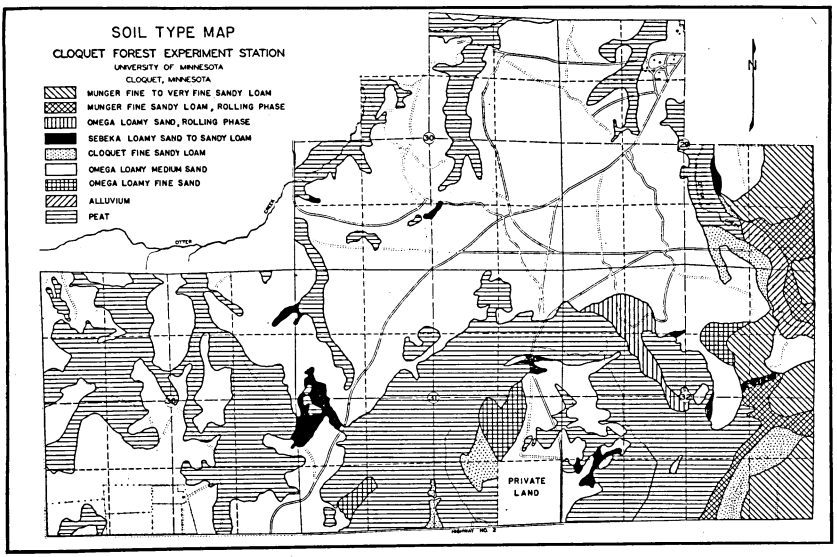

Figure 2

Miami sand (Omega sand) is described as a medium fine sand 6 to 10 inches deep with a subsoil of medium or coarse sand, sometimes grading into gravel beds at 2 to 3 feet. It is a combination of glacial flood plain and morainic material. Miami sandy loam (Cloquet sandy loam) is of medium texture, sometimes mixed with gravel 8 to 14 inches deep. The subsoil is medium coarse, sandy loam grading into gravel beds at 2 to 3 feet. The upper 2 inches of the Munger fine sandy loam is a light gray fine sandy loam grading into a yellowish brown fine sandy loam about 4 inches in thickness. From 6 to 12 inches of the soil is a reddish brown very fine sandy loam containing some coarser material.

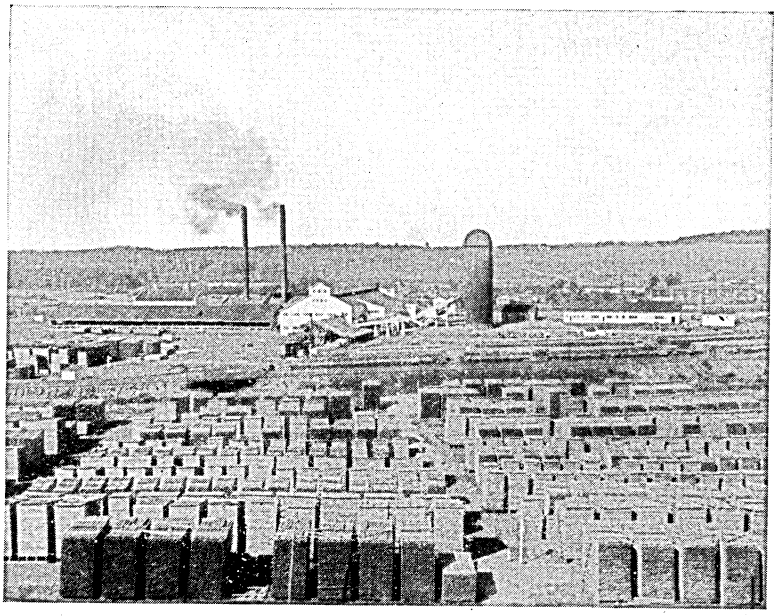

Fig. 3. The Large Mill and Yard of the Cloquet Northern Lumber Company
One outlet for the forest products from the Cloquet Forest. The only large saw mill left of the five original mills in Cloquet. It has an annual output of about 80,000,000 ft. B.M. and is now sawing jack pine and aspen as well as Norway and white pine.

The subsoil consists primarily of fine sand, coarse sand, gravel with pebbles and cobblestones, or a mixture of these.

A study of the soils also has been made in connection with a study of the past and present cover types on the forest.

In general, the soils are too light for agricultural use and may be considered as marginal.

Climate.—The forest lies 25 miles west of the western end of Lake Superior. This is far enough inland to lose most of the ameliorating effects of the lake in the winter and yet close enough to feel the retarding effect of the lake in the spring. The prevailing wind direction at different seasons is doubtless the cause of this paradox. During the spring the prevailing winds are from the northeast, but they are from the northwest during the remainder of the year. The thunderstorms of summer come from the northwest, but a northeast wind at any time of the year usually brings a three-day period of precipitation. The mean annual rainfall is 26 inches. The usual maximum temperature is 90 degrees F., usually occurring in the month of August; the usual minimum is —45 degrees F., usually occurring in January or February. The mean annual temperature is 38 degrees F. The mean temperature during the growing season, May to September inclusive, is 58 degrees F. Ordinarily the frostless season extends from June 7 to September 7;

frosts are not unusual during any month except July, and killing frosts have been experienced during every month of the year.

Sufficient snow for snow logging roads may be expected early in November. Often it lasts until late in March. This, of course, influences the logging method used and the time of the year during which logging is carried on. Where advance growth is established, cutting and skidding must be done in the fall and early winter. If it is delayed until very cold weather, the young trees freeze solid and are much more easily damaged.

Neither lightning nor windstorms are especially severe in this region. Lightning is usually accompanied by a heavy rain and consequently is not an important cause of fire.

ECONOMIC SITUATION

Markets.—Cloquet is, and will probably continue to be, the most important wood manufacturing center in Minnesota. The proximity of the forest to such a center (with which it is connected by a good highway) insures, under ordinary conditions, a ready and permanent market for all salable forest products. The forest is, therefore, advantageously located for the practice of forestry.

Four firms engaged in the manufacture of wood products are located at Cloquet: the Northwest Paper Company and the Wood Conversion

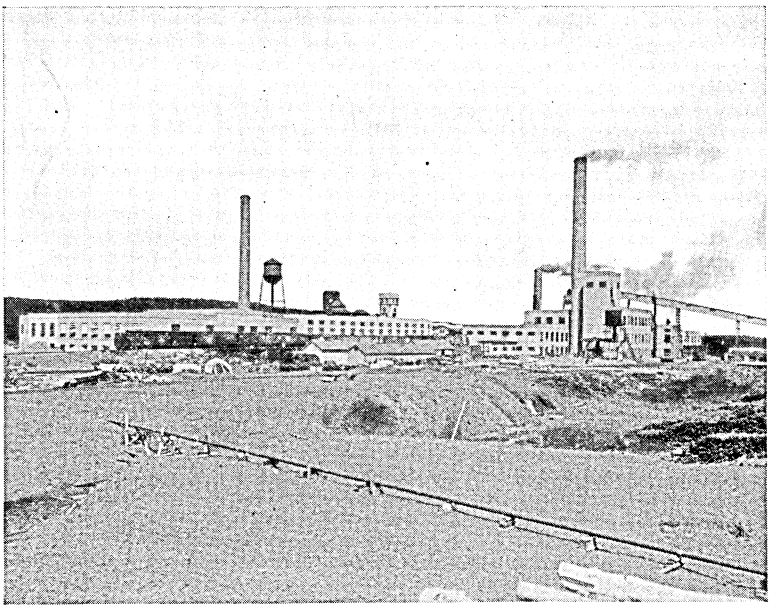

Fig. 4. Northwest Paper Company, Cloquet, Minnesota
An outlet for the jack pine and spruce pulp wood from the Cloquet Forest. This company has found a way to make wrapping paper from almost any species.

Company, both Weyerhaeuser organizations; the Rathborne, Hair, and Ridgway Company, and the Berst, Forster, and Dixfield Company.[1]

The Northwest Paper Company is composed of three distinct units: Mill A, Mill B, and a Pulp and Paper Mill.

Mill A is a three-band sawmill manufacturing lumber. Here logs of white pine, Norway pine, jack pine, spruce, balsam, and aspen are sawed into lumber. Logs with a minimum diameter of 6 inches and a minimum length of 10 feet are taken by this mill. The normal annual capacity is 80,000,000 feet B.M.

Mill B is a bolt mill for sawing small logs and box bolts to supply the lumber specialties division with material for crating and box lumber. At this plant jack pine, spruce, balsam, and aspen are sent through Swedish gang saws. Bolts 110 inches (9 feet, 2 inches) long, with a minimum diameter of 4 inches, are taken by this mill. The normal annual capacity is about 30,000,000 feet B.M.

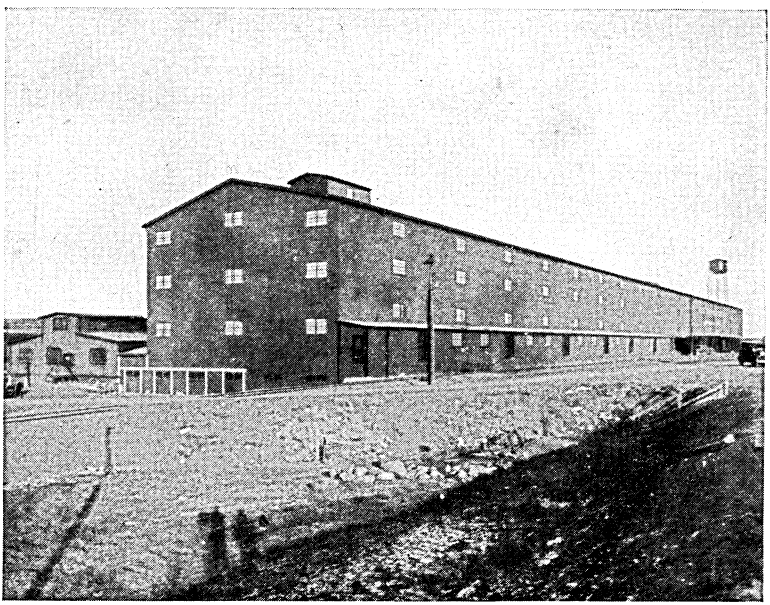

Fig. 5. Wood Conversion Company, Cloquet, Minnesota
This plant, said to be one of the largest frame buildings in the world, may be an important factor in furnishing a market for the so-called "inferior woods" of northern Minnesota.

The paper mill manufactures various book, writing, and wrapping papers. Sulphite, sulphate, and soda pulps are made. The soda-sulphate mill uses aspen and jack pine; the sulphite mill operates almost entirely on spruce. The annual wood consumption of the sulphite mill is 40,000 cords, and of the soda-sulphate mill 45,000 cords.

[1] Since 1929, important changes in wood utilization have occurred at Cloquet. Mill A has been replaced by a singleband mill; Mill B is not operating; the box factory has moved from Cloquet; the Wood Conversion Co. now purchases much of its raw material in the form of cordwood; the Berst, Forster, and Dixfield Company now uses as much or more aspen than birch.

The Wood Conversion Company manufactures "balsam-wool," a flexible insulating material, and "Nu-wood," an insulating wall board. These products are manufactured largely from screenings from the paper mill and "hog feed" from the saw mills. Because both are normally waste products, it is difficult to give any figure as to the total wood consumption of this plant. As the markets develop, there is a possibility that wood will be purchased directly for the manufacture of these products.

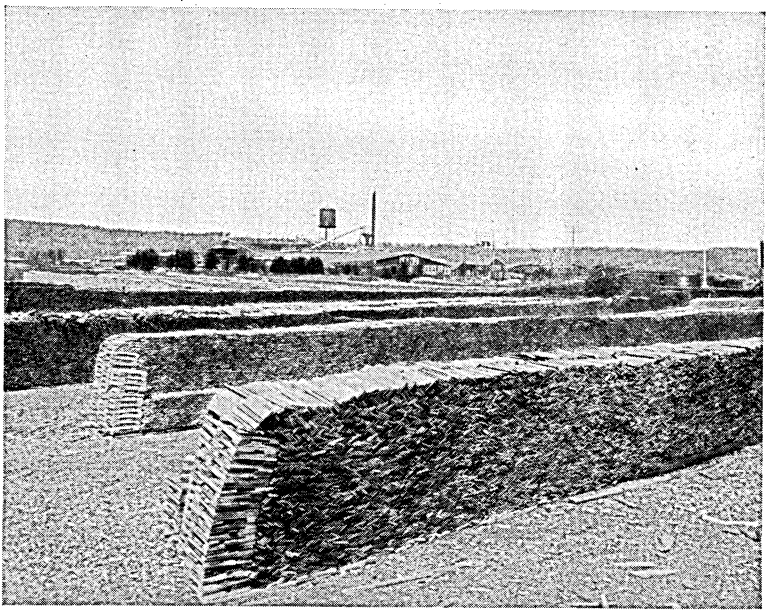

Fig. 6. Rathborne, Hair, and Ridgway Company, Cloquet, Minnesota
Manufacturers of boxes and box shooks. This industry makes possible the utilization of small and short bolts. This is a possible market for thinnings.

The Rathborne, Hair, and Ridgway Company manufactures boxes and box shooks. The plant is equipped for re-manufacture only, and obtains its material from the short lengths produced by the two sawmills of the Northwest Paper Company, through purchase from portable sawmill owners in the vicinity, and from the company's own mills at Deer River and Cass Lake, Minnesota. Under normal conditions this plant re-manufactures annually about 20,000,000 feet B.M. into boxes and box shooks.

The Berst, Forster, and Dixfield Company manufactures toothpicks, clothes pins, physicians' supplies, and matches, and is at present building a plant for the manufacture of paper dishes. About 4,000,000 feet, of which less than one-fourth is aspen and the rest birch, are now used

annually. With the opening of the new plant, spruce or spruce pulp will be used for the manufacture of paper dishes. The birch and aspen is purchased in 8-foot lengths to a minimum diameter of 6 inches.

The complete utilization of wood waste by the different wood-using industries creates a shortage of mill fuel wood in the city, and makes it possible for the Cloquet Forest to sell quantities of fuel wood.

Fig. 7. Berst, Forster, and Dixfield Plant, Cloquet, Minnesota
Manufacturers of toothpicks, clothes pins, matches, birch novelties. This plant furnishes a splendid market for white birch and popple logs.

These markets, together with the forest's small portable mill for sawing logs too small or too defective to pay for hauling them to town, furnish a ready outlet for almost any product which the forest may produce.

HAZARDS

The hazards incident to the production of forest crops are many. Constant watchfulness, intelligent preparedness, and efficient management will do much to overcome these hazards. There are five general classes of destructive agencies, namely, fire, disease, insect pests, animal pests, and wind and weather. Of these, fire is the most important.

The Fire Hazard

The fire records show that during the last 15 years the spring fire season has varied from 0 to 3 weeks. Five of the 15 years have had no severe spring fire season. The fall season has varied from 0 to 4

weeks. Six of the 15 years have had no severe fall fire season. Fire scars on the mature Norway pine bear witness to severe fires in 1819, 1842, 1885, 1864, 1874, and 1894. These were apparently dry years when fires were common. As a result of these fires, a large part of the area was repeatedly burned over. Probably there were many other fires of which the fire scars show no record.

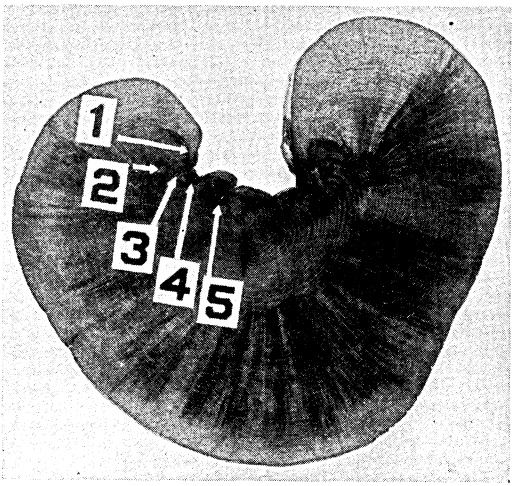

Fig. 8. Section of 100-Year-Old Norway Pine, Showing a Record of Five Fires, Which Occurred in 1842, 1855, 1864, 1874, and 1894

There is a jack pine stand on the station as the result of each of these fires.

The boundaries of the forest are quite well protected by physical barriers which prevent fires from sweeping in. The entire south boundary, except for the one alienated forty, is paralleled by a county highway. This is a four-rod, gravelled road which is sufficiently wide to catch burning cigarette butts on the gravel. The west line of Section 36 is paralleled by a two-rod township road which is not heavily traveled. Otter Creek follows the north boundary quite closely. From the northwest corner of the forest to the point where it crosses the north line of the SE¼ of Section 29, Otter Creek flows through meadows varying from 1/16 to 1/4 mile in width. During the summer and usually during the spring fire season, these meadows are a barrier. At times when the water level is low and the grass dry, a condition usually confined to late summer and fall, they become a hazard. The boundary of the SE¼ of Section 29 is paralleled by narrow roads. The east line of 32 has a two-rod firebreak well seeded to clover. Thus adequate natural or artificial barriers exist on all boundaries of the forest, with the possible exception of the north line of the SE¼ of Section 29.

An 85-foot steel lookout tower is located in the northwest corner of the SE¼ of NW¼ of Section 32. This tower is manned by the State Forest Service during the danger season. Telephone connections are maintained with the forest headquarters as well as with the state ranger's office. The entire forest is visible from the tower, which eliminates the need for patrol even during the danger season.

Since the establishment of the station in 1909, a record of fires has been kept. These records show that two of the largest fires came in from the outside. The others resulted from the carelessness of berry pickers and picnickers. Since the Cloquet fire of 1918, the attitude of the public towards fire in the woods has changed for the better. Picnickers in general are now more careful and their camp fires are largely restricted to specially prepared fireplaces.

Demonstration forests such as the Cloquet Forest must of necessity be protected from fire as completely as possible. However, even with adequate protection, fires will at times occur. When they do occur, they must be kept small by quick detection and effective suppression. During the last 10 years, a total of only five acres of the forest have been burned, which is less than two-tenths of one per cent.

Large areas of high hazard, such as unburned slash, do not exist on the forest. The material most likely to become inflammable is the northern fern brake which dries out quickly after the first frost in the fall and is often standing in the spring.

Fires result from four main causes: smokers, picnickers, brush burning, and railroads. The first two can be classed as both external and internal causes.

The probability of fire originating from these sources is as great within the boundaries as without. Fire caused by brush burning and railroads will always originate without the forest boundaries.

Just how important smokers are as a potential cause of fire is not known. In all probability the "smoker" fires will originate along the well-traveled roads. Fortunately, the graveled right-of-way is ordinarily wide enough to catch the matches, cigarettes, and cigar butts.

Picnickers present a real problem. During the spring fire season, people swarm the woods in search of arbutus and other spring flowers. At this time of the year, the weather is not suitable for long picnics, consequently very few camp fires are built. During the summer when the blueberries are ripe, there is more extended picnicking, but less fire hazard. During the fall season, there is very little picnicking on the forest except on established picnic grounds.

The Northern Pacific Railway, which parallels the south boundary at a distance of three-quarters of a mile, is not a serious hazard because

of this intervening distance and two four-rod roads between it and the forest. Only in periods of extreme danger might it become a serious menace.

Theoretically, at least, the third cause of fire, brush burning, is a passing one. Brush is usually burned during logging and land clearing. Logging is a thing of the past in the region adjoining the forest. Land clearing, however, is still an important cause of fires. During the 20 years since the forest was established, less than one-half of the land along the boundaries has been cleared. For years to come, therefore, land clearing will no doubt actually be an important cause of fires.

Fig. 9. Public Picnic Ground on the Cloquet Forest
The forest is used as a recreation ground by hundreds of visitors. This is a stand of 110-year-old Norway pine.

Only through education of the public can fires originating within the boundary, from carelessness, be prevented. This education is being attempted partly through the erection of fire-warning signs along the most traveled roads and near picnic grounds. The local people who use the forest as a recreational area take pride in the forest, and, as a whole, are careful. It is the stranger and the tourist who must be reached. Educational work without the forest is left, of course, to the state ranger stationed at Cloquet.

The state ranger and the forest personnel cooperate closely in the matter of fire suppression. During the spring fire season, there are from 25 to 50 students on the forest, but during the fall season, there are usually only 5 men, including the technical staff. Ten settlers living near

the forest are available for fire fighting and can be called by telephone. In case of a serious fire, help would be available from the mills in town.

The present fire-fighting equipment is sufficient for 10 men. It is housed separately from all other equipment and is always available for instant use. The outfit consists of six long-handled shovels, three short-handled shovels, two mattocks, two axes, two Kortick fire tools, one gasoline fire torch, five chemical fire extinguishers, and six five-gallon hand pumps. There are also two 175-gallon tanks mounted on trailers which can be hauled to the fire for recharging the extinguishers and servicing the hand pumps.

At present, all points of the forest are within half a mile of roads traversable by truck or car.

Fungous Diseases

The organisms that attack different parts of the tree are numerous. From the standpoint of forest management, there are two types of diseases—those which affect the quality and quantity of the product, and those which kill the tree. As far as is known, the losses caused by fungous diseases on the Cloquet Forest are not very heavy at the present time.

Heart rot (*Trametes pini* [Brot.] Fr.) occurs commonly in overmature white and jack pine. Losses caused by heart rots can be effectively controlled by cutting the trees at a reasonable age, by proper forest sanitation, and by keeping the trees vigorous and healthy through proper thinning.

Jack pine rusts (*Cronartium comptoniae* Arth. and *Cronartium pyriforme* [Pk.]) are common, especially in the young, dense stands of jack pine. Sweet fern, the alternate host for at least one of these rusts, is abundant on the forest, making it impossible to carry out control measures except at a prohibitive cost. Fortunately, the damage caused by these diseases is not great.

White pine blister rust (*Cronartium ribicola* Fisch.) is not known to exist on the forest, but it has been found near it. Some *ribes* have already been eradicated and further measures will be taken as the necessity arises.

Altho the spruce needle rust is found from time to time, its control, as well as the damage that it does, are still a matter of conjecture.

The shoestring fungus (*Armillaria mellea* [Vehl.] Quel.) causes considerable loss in both plantations and in natural reproduction. However, it usually occurs in isolated patches, killing only a portion of the trees. No control measures have been developed as yet.

Good forest management resulting in thrifty mixed stands, with little dead and down material, will do much to control fungous diseases.

Insect Pests

At present no insect epidemic threatens the forest. The larch saw-fly *(Lygaeonematus erichsonii)* destroyed most of the mature tamarack about 1910-1914. Since then it has been present each year, but not in epidemic form.

The jack pine saw-fly (*Neodiprion* sp.), apparently the variety which confines its attacks to the seedling trees, is found in small numbers each year. The presence of this insect should be watched carefully, since it apparently will also attack young Scotch pine and Norway pine. In areas where it has been found on seedling jack pine the larvae have been gathered and destroyed.

The white pine weevel *(Pissodes strobi)*, aphids, and jack pine blister beetles are present in small numbers. Occasional bark beetles and borers are found, but none of these have ever been serious. The spruce bud worm *(Hormologa fumiferana)* has not been found on the forest.

The best control and protection against insect pests is, as in the case of disease, the maintenance of thrifty, mixed stands. Care should be taken to detect the occurrence of any insects in epidemic form. In the early stages of any insect outbreak, it is often possible to apply control measures which will prevent a serious loss.

Animal Pests

In a small area such as this, forest animals usually do not cause serious losses. There is some evidence of damage by porcupines, squirrels, beaver, and deer, but it is negligible. However, snowshoe and cottontail rabbits are numerous and do considerable damage to young plantations and natural reproduction. The rabbit population is at times quite large. During one season a rabbit hunt on about 120 acres of the forest netted 300 rabbits. As often happens throughout the country, they become diseased from time to time. This reduces the rabbit population and allows the young trees to become established. Both terminal and lateral shoots are eaten by the rabbit; in many plantations 100 per cent of the trees are so damaged. Repeated attacks eventually kill the tree. No adequate control measures have as yet been developed.

Porcupines, not more than a half a dozen in number, girdle a few trees each year, usually the tops of mature jack pine.

In seasons when the cones are not abundant, red squirrels do some damage by stripping the bark of jack pine. Very often they also tear the terminal buds from the branches of mature Norway pine.

There is one colony of beaver at present on the forest, but, as yet, they have not become numerous enough to do any damage.

Deer are not present in sufficient numbers to be a problem, or are they likely to become a pest on such a small area.

Wind and Weather

Nothing can be done to control the wind and weather. These factors, however, must be taken into consideration in the silvicultural treatment of the forest. They are capable of causing serious damage, especially in the swamp types.

OPERATING FORCE

The forest is under the direct charge of a resident forester. He has a full-time foreman and a crew that varies in size with the season of the year and the amount of work to be done. Most of the cutting is let as piece work. A number of settlers adjacent to the forest are well fitted by experience and temperament to do this work.

DESCRIPTION OF THE PRESENT FOREST

For purposes of description it is possible to classify the forest into the nine following cover types: (1) jack pine; (2) Norway pine; (3) Norway–white pine; (4) mixed conifers and hardwood upland; (5) aspen; (6) black spruce; (7) tamarack; (8) mixed conifer and hardwood swamp; (9) open or non-productive. In Figure 10 the location and distribution of these various types are shown. In Figure 11 and Table 1 are shown the areas of these types. The area of each age class is shown in Figure 12 and Table 2.

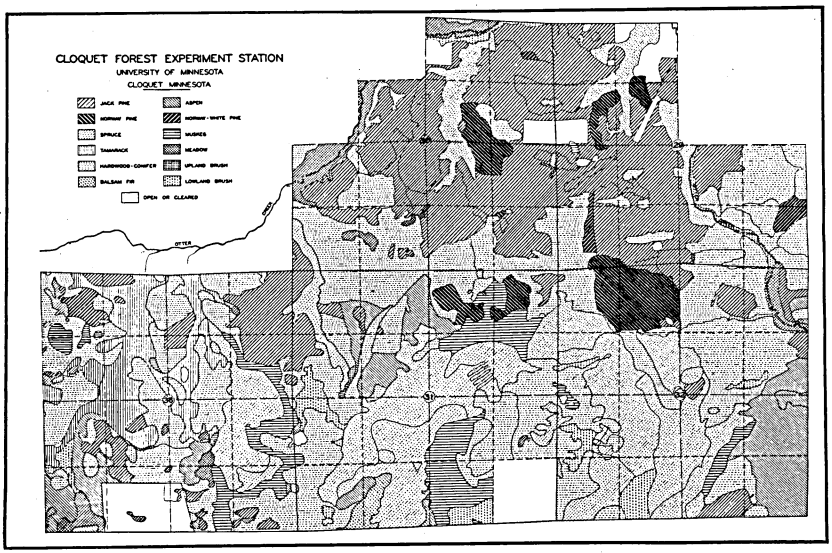

Figure 10

Not all of these types are either permanent or desirable, nor will they be found in the managed forest a hundred years hence. They are, for the most part, the result of logging operations or accidents, such as fires or insect attacks. Nevertheless, they are a part of the forest as it exists today and must be given consideration, if the future forest is to be understood.

The Jack Pine Type

Practically all the jack pine stands found on the Cloquet Forest originated as the result of forest fires. A study of the fire scars on the old Norway pine trees shows that there have been six heavy fires on the station tract in the last 120 years. These fires occured in 1819, 1842, 1855, 1864, 1874, and 1894. Each fire was responsible for the establishment of a considerable area of jack pine. The stands occupying these areas are now 35, 55, 65, 75, 85, and 105 years old.

Where jack pine makes up at least 80 per cent of the stand in volume, it is called a pure stand. A large part of the jack pine stand is of this character. When such stands are young, they are so dense that they seldom contain any other species, no large brush and no reproduction. As they

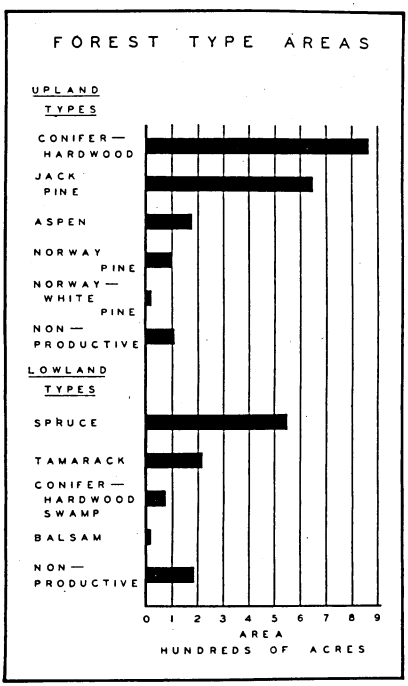

Fig. 11. Distribution of Upland and Lowland Forest Type Areas

The most important types on an area basis are the conifer-hardwood and the jack pine, on upland sites, and spruce on the lowland sites.

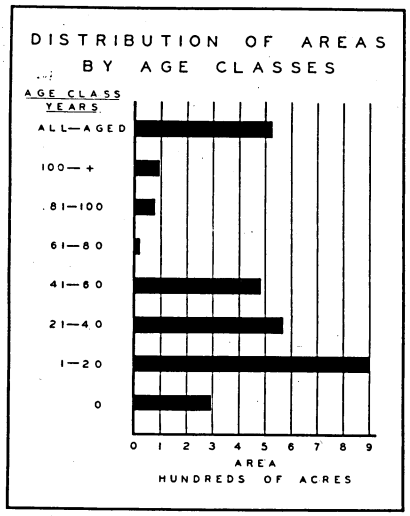

Fig. 12. Distribution of Areas by 20-Year Age Classes

The surplus area in the 1–20-year age class, and the deficit in the age classes over 60 years are clearly shown. The non-productive area is appreciable. The subdivision of the forest area into all-aged and even-aged forest is shown.

grow older the density decreases through natural thinning to the point where other species, especially Norway pine and black spruce, come in as an understory and eventually overtop the jack pine and block it out of the stand. Seldom does the stand get thin enough for the jack pine itself to reproduce.

Fig. 13. Typical Stand of Jack Pine in the 21–40-Year Age Class
This stand has an estimated volume of 24 cords per acre and is about 40 years old. A ground cover of bracken fern and scattered brush is typical of this type.

The ground cover consists chiefly of sweetfern, blueberry, and wintergreen. In open stands, where there is sufficient moisture, hazel, pin cherry, and tag alder may be found in varying degrees of density.

Approximately 651 acres of the station tract are classed as jack pine. Most of it is growing on a light soil which corresponds to a medium site. The stands may be grouped into four 20-year age classes, as follows: 1-20 years, 112 acres; 21-40 years, 248 acres; 41-60 years, 266 acres; 61 years or older, 25 acres.

The ease with which the species reproduces from seed from felled trees points to "clear-cutting" as the cheapest and most satisfactory method of reproduction.

The Norway Pine Type

The Norway pine type, at one time much more extensive than it is now, covers only 99 acres on the Cloquet Forest. Fire and logging have converted large areas of it to jack pine, aspen, or mixed hardwoods and conifers.

It consists very largely of two age classes. On 79 acres the timber is more than 100 years old. This is a remnant of the virgin stand left by the logger. The other 20 acres are mostly from 1 to 20 years old. A heavy seed year just before logging is responsible for this dense stand of young growth.

In addition to these pure stands there is a considerable area of young aspen and jack pine—much of it on the Norway pine land which was cut over before a seed year—under which the Norway is slowly coming in as an understory. This will eventually be converted to Norway forest. The area of this type is also being increased by planting. In the future the tract will therefore contain more of the Norway type.

Fig. 14. The Largest Body of Mature Norway Pine On the Cloquet Forest
The stand covers approximately 60 acres and runs about 15,000 feet per acre. Very little underbrush is present. The last of five fires burned through this stand in 1894.

The underbrush of the Norway type is made up of hazel, blueberry, and honeysuckle on the highlands, and alder on the moister locations. The ground cover is largely wintergreen and grasses.

The Norway–White Pine Type

The Norway–white pine type covers a very small area, only 17.5 acres. The proportion of white pine varies from a few scattered individuals to almost pure stands. On most of the area Norway pine predominates. If it had not been the only place on the station where ma-

ture white pine is growing, it would probably have been grouped with the Norway pine type. But it would be so grouped only on account of its small area. There is at least one essential difference between this area and the Norway pine type. The soil contains a larger proportion of clay. In this climate of low rainfall such a soil is required by white pine.

This type, nowhere very dense, covers the slopes of a narrow, steep-sided, little valley. Because of the understocked condition of the stand and the clay soil, a very heavy stand of hazel and alder brush has come in. This makes it almost impossible to obtain natural reproduction. It is doubtful if even planting can be done successfully here until some method has been devised to subdue the brush.

Fig. 15. Norway Pine Stand 103 Years Old
No underbrush. The last of five fires burned through this stand in 1894. This stand is just reaching the point where natural reproduction is beginning to come in.

The Upland Mixed Hardwood and Conifer Type

This so-called conifer-hardwood type is a temporary mixture of aspen and white birch with jack, Norway, and white pine on the lighter soils, and with spruce and balsam on the heavier soils. The conifers make up from 20 to 60 per cent of the stand. The birch, as a rule, plays a very small part in the mixture.

These mixed stands were probably formed in one of several ways. Some came from the breaking down of an original stand of over-mature jack pine and the occupation of openings in the thinned stand by aspen and birch. In other places fire has killed a stand of jack pine, spruce,

or balsam, and the aspen and birch have occupied the ground. The jack pine came in with them and was able to hold its place by means of its rapid growth. On the heavier soils the spruce and balsam either came in with the aspen and birch or possibly later. In either case they formed an understory which either has already, or eventually will, according to the age of the stand, overtop and replace the hardwoods.

These stands must be regarded purely as a transition type, since their composition is always changing.

If the stand is dense, the ground cover is usually confined to the smaller plants, such as aster, grasses, honeysuckle, and dogwood; but if it is at all open, there may be a dense growth of hazel or alder.

This type occupies 865.8 acres, 110 of which are covered with an uneven-aged stand. This is not strictly speaking an all-aged forest because only a few unevenly distributed age classes are represented. The remainder of the type is covered with more or less even-aged stands, as follows: 546.3 acres, 1-20 years old; 136.8 acres, 21-40 years old; 12.1 acres, 41-60 years; and 60.6 acres, 81-100 years.

The Aspen Type

The aspen type is another phase of the mixed conifer and hardwood type. It is practically a pure stand of aspen now, but it is all less than 40 years of age. As it grows older it will be invaded by an understory of conifers and will gradually pass over into the mixed hardwood-conifer type. There is now a small admixture of white birch. Much of this aspen type is found on the Cloquet sandy loam, the heaviest soil in this forest. The stand is, therefore, thrifty and can be relied upon to reach merchantable size.

The ground cover usually consists of herbaceous plants only, such as the various grasses, clintonia, aster, etc. Hazel and alder are seldom present outside of the openings.

There are 177 acres of this type. Seventy-nine acres are in the 1-20 year age class, and 98 acres in the 21-40 year age class.

The Black Spruce Type

In the Cloquet Forest black spruce is found in pure stands in the swamps and in mixture with balsam and with jack pine on the highlands. Some stands are almost pure balsam, but the area (14 acres) occupied is so small that a separate type is not justified.

In the more open stands the peat is likely to be covered with the dense stand of brush. Alder forms thickets of great density in the larger openings. The smaller openings are filled with Labrador tea, leatherleaf, and swamp laurel.

The trees in a stand may be about the same size and appear to be even-aged, but closer investigation usually shows that there are several age classes present. Of the 562 acres included in this type, 344 acres are many-aged; 132 from 1 to 20 years; 66 from 21 to 40 years; 14 from 41 to 60 years, and 6 from 81 to 100 years old.

Fig. 16. Stand of Mixed Jack Pine and Spruce on Creek Bottom After Partial Cutting Made in 1925-26

Fifty-six per cent of the volume was removed, leaving a stand of about 3,500 board feet per acre. Slash was burned as logging progressed.

The Tamarack Type

The 215 acres of this type consist of 20 acres in the 21–40-year age class and 195 acres in the 41–60-year age class.

Both of these age classes occur on moderately deep peat swamps. They are almost pure, altho along the edge a mixture of black spruce is often found. Because of the thin crown and foliage, considerable light gets through the stand; consequently considerable brush is found in the ground cover (swamp birch, alder, leatherleaf, and Labrador tea).

Originally this species was much more prominent in the swamps of the forest, but the larch saw-fly epidemic of 1910-1914 took a heavy toll.

Mixed Conifer and Hardwood Swamp Type

This is a swamp-border type. It is usually composed of balsam, black spruce, and white and yellow birch. The proportion of species varies considerably from stand to stand. The area of the mixed conifer

and hardwood type, which is now 72 acres, probably will not increase in the future.

Open or Non-Productive Land

Some 294 acres of the forest are now non-productive. Three acres of this might be called "upland brush" on which there are less than 300 trees per acre. The ground is so completely occupied by hazel brush that no tree seedlings can obtain a foothold. All plantings on these areas have failed. Some method of subduing the brush must be devised before these areas can be converted to productive forest.

In the swamps there are 64 acres of lowland brush, mostly dense alder, which present the same problem as their upland neighbor. Balsam may invade this area in time, but it is a very slow process and of doubtful success.

In potholes and along the edge of Otter Creek there are 65 acres of treeless meadows. The potholes usually carry a dense growth of sedge, while the creek meadow, by far the larger area, bears a fair crop of wild hay. Frosts in the potholes and annual spring floods along the creek make the introduction of valuable species difficult.

Fifty-seven acres of the nonproductive land are classified as muskeg. This is an open, peat swamp type with a heavy growth of leather leaf, dotted here and there with stunted black spruce and tamarack trees. Drainage might make these areas more

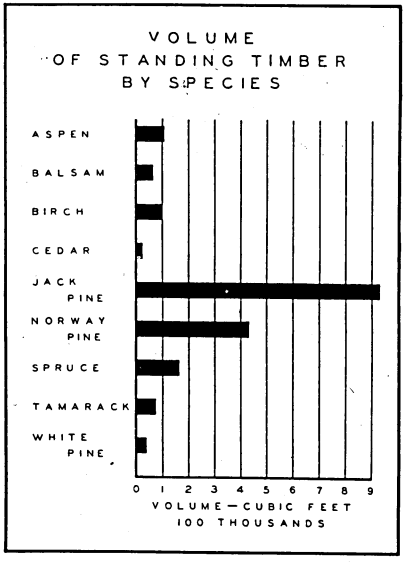

Fig. 17. Distribution of Volume of Entire Wood Capital in Cubic Feet, by Species

On a cubic-foot volume basis, jack pine is the most important species in the forest.

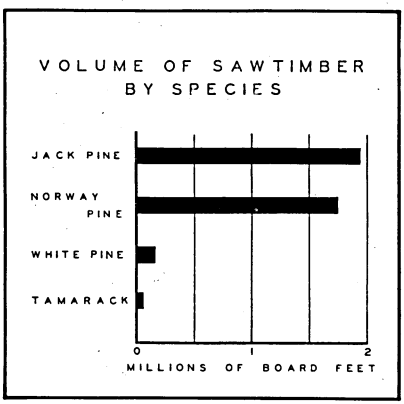

Fig. 18. Distribution of Saw Timber in Board Feet by Species

On a board-foot volume basis, jack and Norway pine are the most important species in the forest.

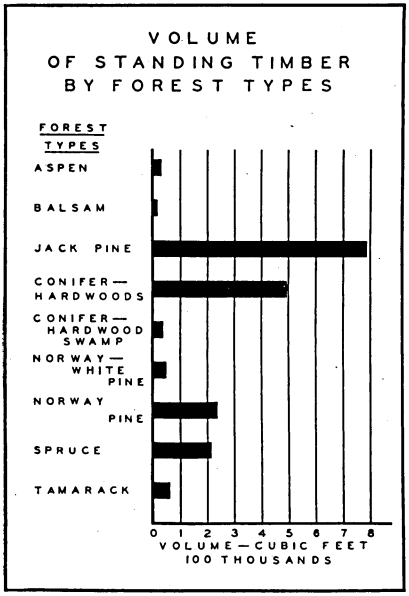

Fig. 19. Distribution of Volume of Entire Wood Capital in Cubic Feet by Forest Types, Including Sawlog Trees

On a cubic-foot volume basis, the jack pine and conifer-hardwoods are the most important forest types.

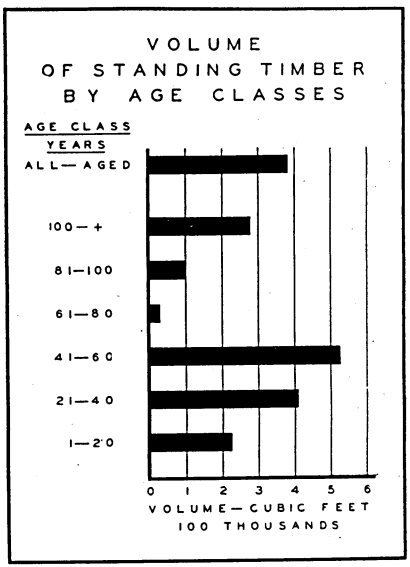

Fig. 20. Distribution of Volume of Entire Wood Capital in Cubic Feet, Including Sawlog Trees by 20-Year Age Classes

Note the deficit of growing stock in the 61–100-year age classes.

productive, but there is no assurance of financial success.

In addition to these naturally non-productive areas, some 67 acres have been cleared for a nursery and forage fields. They can be successfully planted whenever it seems desirable to do so.

The Timber Volume of the Forest

The volume was calculated in three different units of measure: the board foot, cubic foot, and cord. The contents of tamarack, jack, white, and Norway pine above 7 to 8 inches, depending on the species, were calculated in board feet. The volume tables used in these calculations were based on the Scribner Decimal C log rule and a top diameter of 6 inches. For purposes of comparison, the total volume (including the saw timber) of all trees 3.6 inches and above in diameter is given in cubic feet. The cubic volume includes the bark, but excludes the stump and the top above 3 inches. The cubic-foot volume of species other than white and Norway pine was converted into cords by assuming that a cord of aspen contains 70 cubic feet and a cord of other species 90 cubic feet. The estimated volume of wood of each species in 1929 is given in Table 3 and Figures 17 and 18, and the volume by forest types in Figures 19 and 21.

The total volume of tamarack, jack, white, and Norway pine

lumber in standing timber was estimated at that time to be 3,920,000 board feet; the total volume in cubic feet of all species including trees of sawlog size was 1,910,000 cubic feet, and the volume in cords of all species except white and Norway pine was 16,300 cords. For the area in forest, these totals are equivalent to the following volumes per acre: 1,500 board feet, 720 cubic feet, 6 cords. A summary of the total volume in each 20-year age class is given in Table 4 and Figures 20 and 22. Tables 5 to 15 give the total volume and the volume per acre for each species and age class in each forest type.

The estimated volumes just given include a stand of virgin Norway pine known as the "Camp 8" stand. As it is planned to retain this stand as long as possible as an example of the virgin forest which once covered a large portion of the Lake States region, it will be excluded from the ordinary cutting operations. Only dead and dying trees will be cut in this stand. Since the management plan for this forest calls for excluding indefinitely this "Camp 8" stand, its volume of 160,000 cubic feet or (720,000 feet B.M.) should be deducted from the estimate. If this is done, the total volume of timber on the forest is estimated to be 1,750,000 cubic feet, of which amount 3,200,000 feet B.M. are sawlogs.

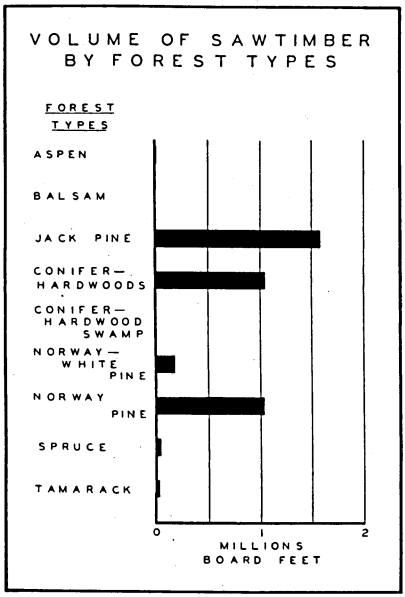

Fig. 21. Distribution of Volume of Saw Timber in Board Feet by Forest Types

On a saw-timber basis, three types are important—Norway pine, conifer-hardwoods, and jack pine.

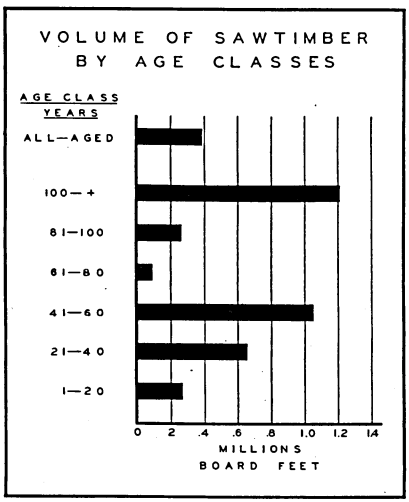

Fig. 22. Distribution of Volume of Saw Timber in Board Feet by 20-Year Age Classes

The deficit in the growing stock in the 61–100-year age classes is clearly shown.

THE MANAGEMENT PLAN

Object of Management

The primary object of the Cloquet Forest is to demonstrate the physical and financial possibilities of growing timber in the cut-over region of northeastern Minnesota.

The markets available to the forest will take, within certain limits, wood material of any size or quality. Because a knowledge concerning the practicability of growing Norway, jack, and white pine sawlogs and jack pine pulpwood on the upland soils, and of growing spruce pulpwood on the lowland soils, is necessary to determine the timber-growing possibilities of the region, the production of these classes of materials will be given first consideration in the management of the forest. The Cloquet Forest is well suited for this purpose, because these species will grow well on a large part of the area.

The Cloquet Forest must also serve as a field experiment station for research work in forestry. Much additional information is urgently needed concerning the effects of different methods of thinning on the growth and yield of various species. How to obtain satisfactory reproduction of the forest on areas covered with dense stands of hazel or alder brush at reasonable cost is another important problem awaiting solution. The solution of these problems, and many others, must neces-

Fig. 23. The Forest Arboretum in 1925

It is hoped that this arboretum, which parallels the main road through the forest, will some day contain all the trees and shrubs which can be grown at Cloquet.

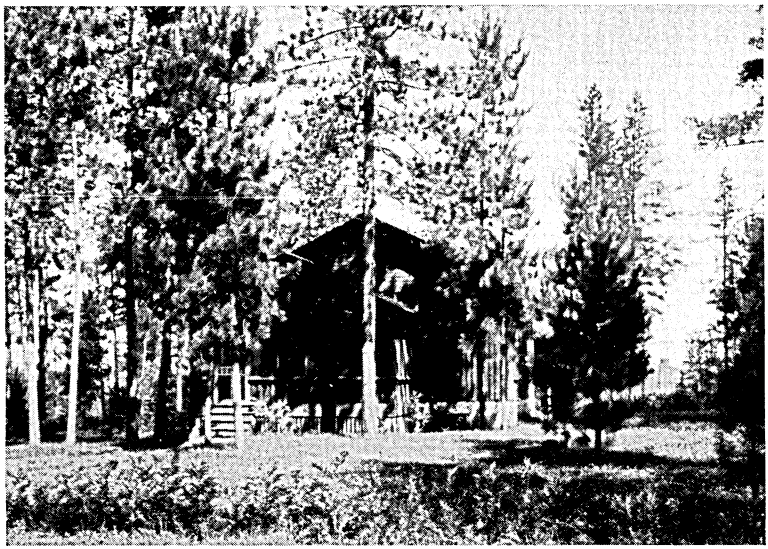

Fig. 24. Club House for Visitors and Faculty
The use of the forest by faculty members and other research workers makes it necessary to furnish quarters for them on the grounds.

sarily receive consideration in the program of work to be carried out on this forest.

The Cloquet Forest has an obligation to fulfill to the people of the state in preparing and maintaining living demonstrations of different forest practices. With this in mind, plots demonstrating different methods of thinning, different methods of regenerating stands, and different methods of slash disposal have all been, or will be, established. An arboretum of native and exotic trees is being developed. The effectiveness of these demonstrations is best attested by the fact that a large number of people view them. Because detailed records of production costs, amount of labor required, and volume of production are kept, these demonstrations will ultimately play an important part in the formulation of future forest practices in this region.

The Cloquet Forest since its acquisition has also been, and will continue to be, used as a field laboratory for graduate and undergraduate students of forestry at the University of Minnesota.

The above activities must all have their places in the management of the forest, but they must not for a moment be allowed to obscure the main object of the working plan, which is to carry out the policy of continuous cutting and to place the forest on a sustained yield basis eventually.

Division of the Forest Into Compartments

The smallness and compactness of the area make it possible to put the whole Cloquet Forest under one plan of management. The forest is divided into 40-acre tracts based upon the section survey lines. Because of its convenience as a unit of area subdivision, the forty will be used as the compartment unit. The forties (compartments) have been numbered consecutively, as shown in Figure 25. All information for each compartment is kept up to date in the Compartment Record Book in the forest office.

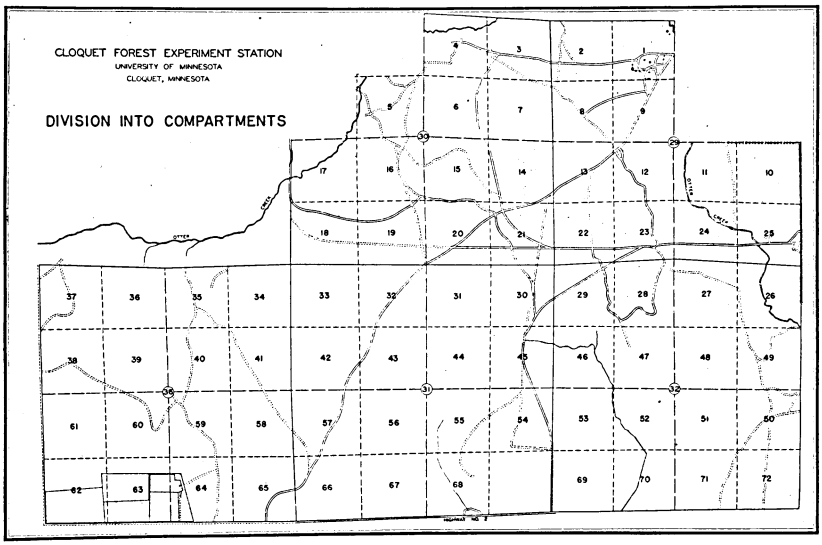

Figure 25

Silvicultural Plan

Planting plan.—The planting work necessary on the Cloquet Forest can be divided into three classes: (1) the restoration of areas cut over and burned over and not restocking satisfactorily; (2) the planting of areas cut under management where a change in the character of the stand is desirable; (3) the underplanting of stands of jack pine and aspen with more desirable species.

The type map of 1929 shows four types which, according to the description, are either wholly or partially non-productive. These types are called upland brush, lowland brush, muskeg, and meadow. Muskegs and meadows comprise an area of 57 and 65 acres, respectively. As these types can be truly classed as non-productive, they need not be considered at this time. In the light of present knowledge, they can not be made productive with an expenditure commensurate with the returns.

Fig. 26. Fifty-four-Year-Old Jack Pine Lightly Thinned and Underplanted With White Pine, Survival 90 Per Cent

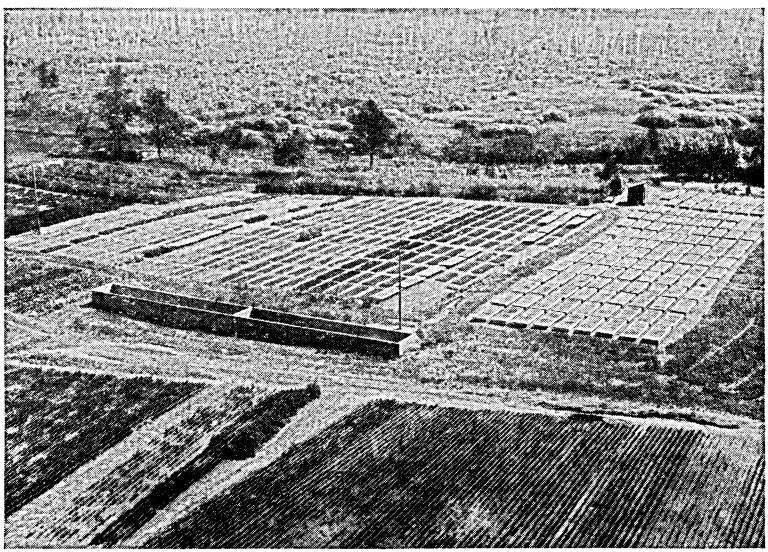

Fig. 27. Bird's-eye View of the Forest Nursery and the Cut-over and Burned-over Area Outside the Forest

The upland brush type covers an area of three acres, scattered through the forest. A dense stand of hazel has come in and apparently occupied the area to the exclusion of all tree growth. The lowland brush, largely tag alder, covers an area of 64 acres. Neither of these types can be successfully planted without some pre-treatment of the brush. No successful method of handling the brush has as yet been developed.

In a few stands of jack pine or aspen which are to be clear-cut, more desirable species should be planted. In some stands underplanting before the stand is removed may be more desirable. This must be determined for each case. In no instance should underplanting be carried out more than four years in advance of the removal of the overhead stand. Approximately 270 acres of aspen and 490 acres of jack pine type should be converted by underplanting to either Norway or white pine type. Because of the expense involved in planting, it will be advisable to confine the planting work of this class to those areas where it is doubtful whether natural reproduction will come in after clear-cutting. Otherwise natural means should be relied upon to convert the stand.

Direct seeding has not been successful on the forest; consequently planting, using either 2-1 or 2-2 stock, will be the method of artificial regeneration used. Two-1 stock should be used on the open sites; 2-2 on brushier sites. All the stock will be raised in the forest nursery. Norway pine, white pine, and white spruce should be used on upland

Fig. 28. A 27-Year-Old Jack Pine Stand In Need of a Thinning

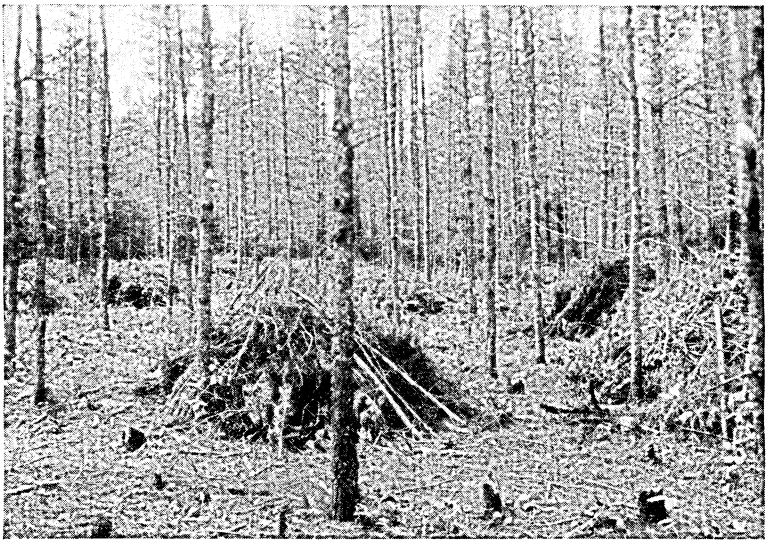

Fig. 29. An Experimental Thinning Made in 1924 in the Same 27-Year-Old Stand of Jack Pine
Of the original stand of 2,478 trees, 768 trees per acre were left.

sites; cedar, tamarack, and black spruce on the lowland. Enough natural reproduction can be relied upon to provide a satisfactory mixture.

Cutting methods.—The cutting methods are not specified because, for demonstrational and experimental reasons, as many different cutting methods as offer any promise of success will be tried out in each type. Past experience at the Cloquet Station points to the following practices as deserving of particular attention. The same practice will be followed in making thinnings. So little data are available on thinnings that many different kinds of thinnings will be tried in the different types and at various ages until the best practice has been determined.

Jack pine, with its serotonous cones, lends itself admirably to clear-cutting. Approximately 161 acres of this area, where the soil is very sandy, will be maintained permanently in jack pine.

Altho Norway pine may be reproduced very successfully by clear-cutting after a good seed year, it is not an altogether satisfactory method from a business viewpoint; and it has, moreover, one very serious drawback—reproduction may be too dense. In some 15-year-old stands, which were established in this way, there are as many as 22,000 trees per acre. Such stands, in which adequate thinning would be very expensive, are too dense for good growth.

The shelterwood method would seem to be much better suited to this species, because the amount of reproduction can be more readily controlled and expensive thinnings thereby avoided.

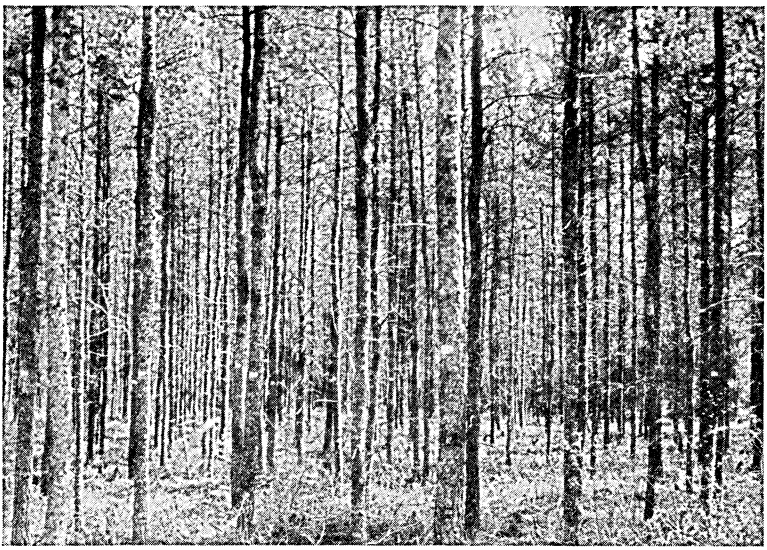

Fig. 30. An Experimental Pruning in a 30-Year-Old Jack Pine Stand to Produce Clear Lumber

Trees for the final cut were selected and pruned as high as possible. The trees marked with paint at breast height have been pruned.

Fig. 31. Thinned 15-Year-Old Natural Reproduction of Norway Pine
Before thinning, there were 18,000 per acre; after thinning, 1,200 trees per acre.

Norway pine will reproduce well from border cuttings. As in the case of clear-cutting, the reproduction is likely to be too dense.

The Norway–white pine type, which is represented by a rather open stand of mature timber, has such a dense stand of underbrush that the establishment of reproduction by any known method is extremely doubtful. Because a little aspen is mixed in with the pine, one possibility exists. If the aspen and pine are cut at the same time, it is possible that there will be a growth of aspen suckers sufficiently dense to thin out the brush. White pine and white spruce could then be planted under the aspen.

Fig. 32. Advance Reproduction Made It Advisable to Cut the Border of This 100-Year-Old Norway Pine Stand

These openings are quite well filled with two-year-old reproduction established since cutting. As the reproduction establishes itself, border cuttings will be continued.

The Upland Mixed Hardwood and Conifer Type

Because of the greater value of pine and spruce in this locality, the upland mixed hardwood-conifer type should be converted to pine and spruce as quickly as possible. This can best be done by cutting out all the hardwoods and some of the mature conifers. In the case of this type, an early cleaning will be necessary in order to free the conifers from the hardwood sprouts. If natural reproduction is not secured within five years, planting must be used to fill out the stand.

Tamarack Swamp

Little is known about the natural reproduction of tamarack, but the fact that it is always found in even-aged stands, often over considerable areas, indicates that this type may be handled satisfactorily under some clear-cutting system.

The Hardwood–Conifer Swamp Type

This type will be maintained as such and managed under the selection system. An attempt will be made to reduce the amount of balsam in the stand, but owing to its vigorous reproduction and great tolerance it probably will always be present in considerable quantity.

Black Spruce Swamp

Some of the black spruce stands are even-aged and others are uneven-aged. The latter will be maintained as uneven-aged stands and will be managed under the selection system. The former will be managed under some form of clear-cutting.

Aspen Type

The aspen will be clear-cut, leaving such conifers as are present for seed trees. Coniferous young growth will be assisted by release cuttings

Fig. 33. Strip-cutting in Black Spruce Swamp, 1928
Cut strips and uncut strips 75 feet wide. Splendid reproduction came in on both the cut and uncut strips.

Fig. 34. Black Spruce Reproduction at the Outer Edge of Strip-cutting, 1931
This reproduction came in following the clear-cutting of a border of the stand in 1922.

as opportunity offers. Because aspen suckers very prolifically, it will probably persist in the mixture for several generations, but in diminishing proportions. Possibly some planting will have to be resorted to if natural reproduction is inadequate. In this way the aspen will eventually be converted to conifers.

Slash Disposal

Along the roads and trails the slash will be piled and burned as made in order to improve the appearance of the forest. Elsewhere it will either be lopped and scattered or left *in situ*.

REGULATION

The theory of sustained yield.—In a forest which has been under good management for a long period, i.e., a forest in which a proper distribution of age classes, proper volume and proper increment is found, the annual cut should approximate the annual growth. The annual cut in a forest that has not been under good management may either exceed or fall short of the annual growth, depending upon whether the forest is overstocked or understocked with mature and nearly mature timber. Hence the purpose of regulation under these conditions is to limit the cut of merchantable products from year to year to such an amount that

the forest will eventually contain the proper area of different age classes, each containing the proper volume of wood and having a normal rate of growth. Ultimately the annual cut should equal the annual capacity of the forest to produce wood. This is sustained yield—the goal of forest management.

In determining the amount of timber to be cut annually from the forest these questions arise: How nearly does it approach the normal or ideal forest? Is the Cloquet Forest overstocked or is it understocked? Does it have the proper distribution of age classes? Is its increment normal?

Some of the more important relationships having a bearing on these questions are shown in Figures 12, 45, 46, and 47, and in Tables 2 and 30.

Rotation.—To determine the normality of the forest, a rotation for each forest type within the forest must first be adopted. By "rotation" is meant the number of years required to grow the desired forest crop. Jack pine, spruce, balsam, and aspen will be marketed chiefly as pulp or box bolt wood; Norway pine and white pine as sawlogs; cedar as posts and poles; birch as toothpick bolts and fuel; tamarack as fuel or railroad ties. Altho two or more of these species are often associated, yet over the larger part of the forest one tree species is dominant.

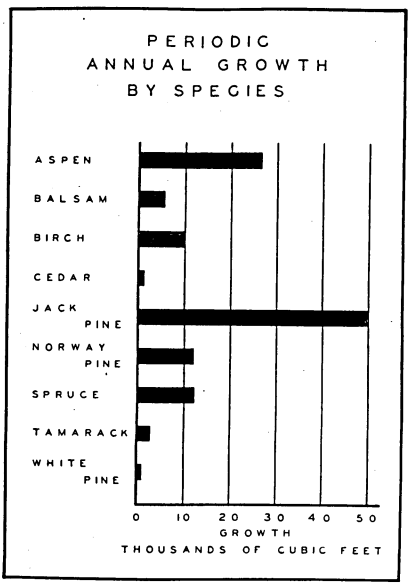

Fig. 35. Distribution of Predicted Average Annual Growth in Cubic Feet for the Period 1930-1939 by Species

Because of the preponderance of jack pine, its total annual production greatly exceeds that of any other species.

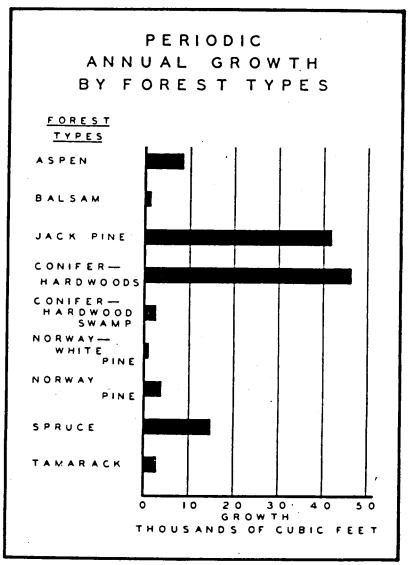

Fig. 36. Distribution of Predicted Average Annual Growth in Cubic Feet for the Period 1930-1939 by Forest Types

Because of the large area of the jack pine and conifer-hardwood types, their contribution to the total annual production of wood greatly exceeds that of other types.

On the uplands, jack pine is now the most abundant tree. The sites occupied by jack pine seem to correspond rather closely to a "medium" site quality. For pulpwood, trees from 6 to 8 inches in diameter breast high are most desirable. Jack pine on medium sites will reach an average diameter of 7 inches breast high in about 60 years. The rotation for jack pine has therefore been set at 60 years.

The growth and yield of other tree species occurring on the forest have not yet been studied as intensively as jack pine. Hence rotations for them can not be determined as satisfactorily as for jack pine. Based upon the best information available, both as to when the growth culminates and as to the number of years required to grow trees large enough for the products desired, a rotation of 80 years has been adopted tentatively for Norway pine, white pine, birch, balsam, cedar, and tamarack; 100 years for black spruce; and 50 years for aspen. These rotations also have been adopted for the type or types in which each of the respective species predominates.

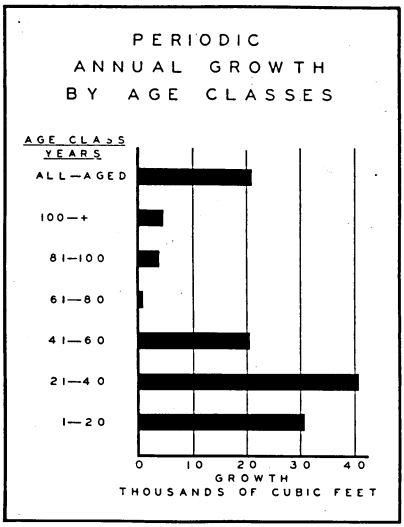

Fig. 37. Distribution of Predicted Average Annual Growth in Cubic Feet for the Period 1930-1939 by 20-Year Age Classes

The younger stands, because of their larger area, produce most of the wood on the forest.

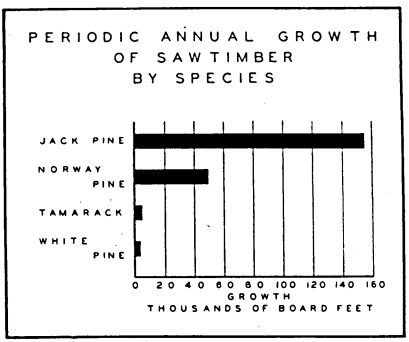

Fig. 38. Distribution of Predicted Average Annual Growth of Saw Timber for the Period 1930-1939 by Species

Jack pine is the most important single producer of saw timber.

Having adopted these rotations, it is possible to determine the normality of the age class distribution in the forest. The data given in Table 2 show that approximately 46 per cent of the total area of upland types, and 31 per cent of the total area of lowland types, is either devoid of trees or bears stands less than 20 years of age. These percentages are excessive, considering the rotations adopted. They indicate a shortage of the middle age and older age classes, and, as a consequence, the total volume of the forest is below normal.

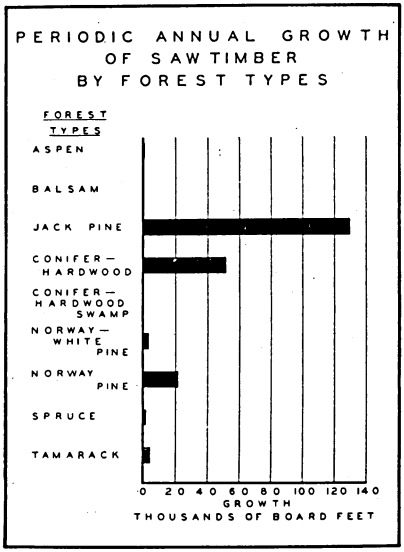

Fig. 39. Distribution of Predicted Average Annual Growth of Saw Timber for the Period 1930-1939 by Forest Types

The jack pine type, because of the large area, annually produces the most saw timber.

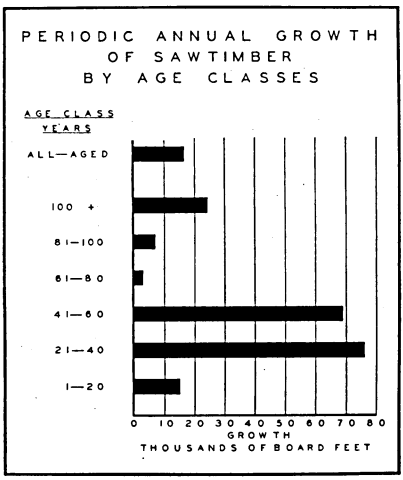

Fig. 40. Distribution of Average Annual Growth of Saw Timber for the Period 1930-1939 by 20-Year Age Classes

The 21–40 and 40–60-year-old stands, because of the large area in these age classes, are producing the most saw timber.

The growth of the forest.—The normality of the volume of the forest may be measured also by the rate of growth now taking place in the forest. A forest managed on a sustained yield basis should, at all times, contain a volume of timber equal to half the total amount which will grow there during a single rotation, providing that no cutting were done during the rotation. On this basis, the Cloquet Forest should contain a stand of timber having a total volume of approximately 4,380,000 cubic feet. The actual volume, 1,750,000 cubic feet, is only 40 per cent of the estimated normal volume. It is evident that the Cloquet Forest is greatly understocked. To build up the volume of timber to approximately what it should be, the cut for many years must be reduced to an amount considerably below the annual growth.

The estimate of the periodic annual growth of the Cloquet Forest for the next 10 years is based upon several hundred cores taken at breast height in the various types and age classes and on the probable number of trees that will die during that time. These data, and those showing the number of trees per acre by diameter and species, were used to determine the forest's probable volume in 1939. From the present and

future volume, the total and average annual growths for the period of 1930 to 1939 were calculated. A summary by species of the average annual growth for this period is given in Table 16.

Table 17 shows the total periodic annual growth by forest types and age classes. The jack, white, and Norway pine, and tamarack over seven inches in diameter, are producing approximately 200,000 feet B.M. each year. The trees over 3.6 inches in diameter of all species are producing 120,000 cubic feet of wood each year. Excluding white and Norway pine, the trees 3.6 inches and larger are producing 1,300 cords a year. This total growth is equivalent to an average growth per acre for the forested area of 75 board feet, 45 cubic feet, or 0.5 of a cord. Considering the fact that only a small part of the actual growth of the 1–20-year-old stands, because of the small size of the trees, is included in the calculated growth, the rate of growth of the forest as a whole is considered quite satisfactory. The growth in volume will increase as the 1–20-year-old stands grow older.

If the "Camp 8" stand of virgin Norway pine, which is maintained as a park forest, is eliminated from consideration, the annual growth of the forest is not appreciably affected.

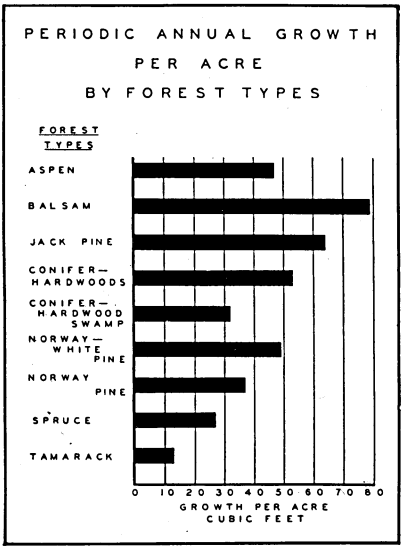

Fig. 41. Predicted Average Annual Growth per Acre in Cubic Feet for the Period 1930-1939 by Forest Types

A lowland species, balsam, is the most productive, and likewise a lowland species, tamarack, is the least productive. The area of balsam, however, is negligible.

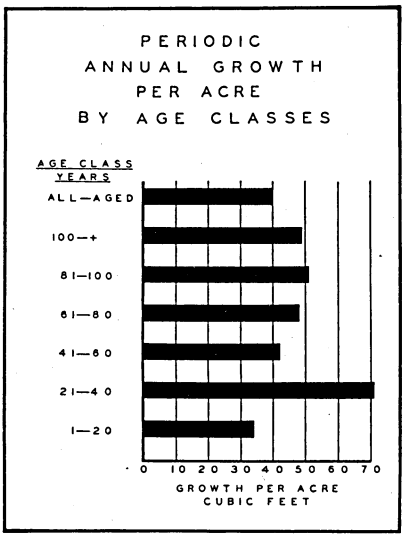

Fig. 42. Predicted Average Annual Growth per Acre in Cubic Feet for the Period 1930-1939 by 20-Year Age Classes

The annual production per acre of the 21–40-year-old stands greatly exceeds that of any other age class.

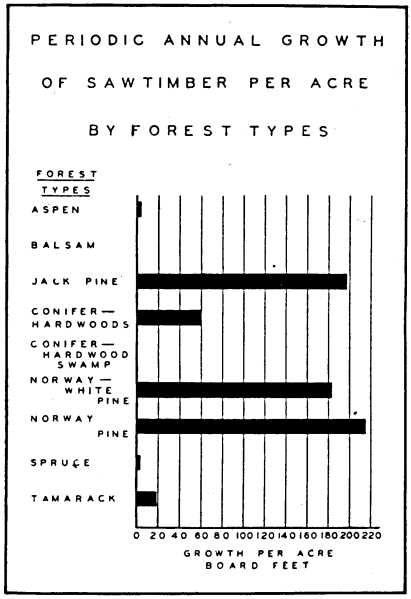

Fig. 43. Predicted Average Annual Growth of Saw Timber per Acre for the Period 1930-1939 by Forest Types

On a per acre basis, the Norway–white pine, the jack pine, and Norway pine types are the most productive saw timber types.

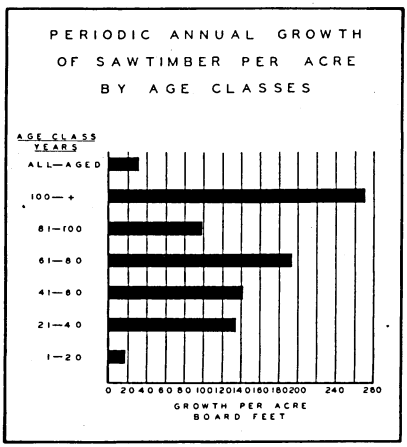

Fig. 44. Predicted Average Annual Growth of Saw Timber per Acre for the Period 1930-1939 by 20-Year Age Classes

On a per acre basis, the stands 100 years old and over are the most important timber producers.

From a growth point of view, the jack pine and the upland mixed conifer and hardwood types are most important.

The periodic annual growth by species, forest types, and age classes is shown graphically in Figures 35, 36, and 37. The periodic annual growth of saw timber by species, forest types, and age classes is shown graphically in Figures 38, 39, and 40. The periodic annual growth per acre by forest types and age classes is shown in Figures 41 and 42. The periodic annual growth of saw timber per acre by forest types and age classes is shown in Figures 43 and 44. The foregoing growth data are also given in Tables 18 to 28.

Regulation of the allowable cut.—A number of factors must be taken into consideration in deciding the proper amount of timber to be cut each year. In this particular case, the present condition of the forest (its departure from normal) is the most important. In order to build up the timber capital to approximate normality within a reasonable length of time, less than the annual growth will be cut each year.

There are a number of methods by which the allowable cut might be calculated. In this particular case, the volume methods seem better adapted to the condition of this forest and the data at hand

than do any of the other methods. Of the available volume methods, the Swedish method and Heyer's variation of the Austrian method best meet the immediate requirements of the forest.

According to the Swedish method, the cut during the first third of the rotation should be equal to the volume of the mature and the overmature timber, plus one-half of the volume of the middle-aged timber.[2] The annual cut, then, is this amount divided by one-third the number of years in the rotation. The middle-aged timber is that part of the stand between one-fourth and three-fourths the rotation age. The actual cut based on this method may be either greater or less than the calculated cut.

Variations in the actual cut from the calculated cut are justified, if the silvicultural condition of the stands makes it desirable to cut more or less than the amount calculated. Owing to the Cloquet Forest's marked understocking, the cut should in most cases be less. The allowed cut, calculated by this method, is given in Table 29. The cubic measure includes trees too small to be included in the board measure table.

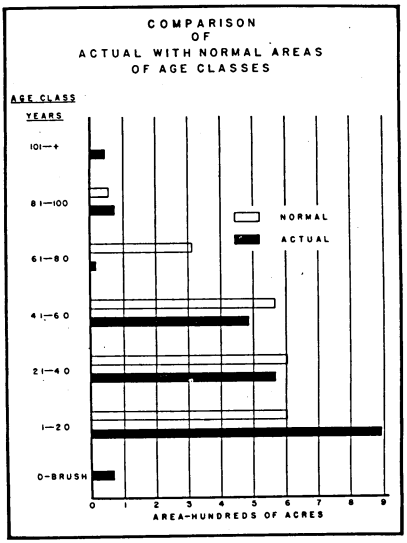

Fig. 45. Comparison of Actual with Normal Areas of Age Classes

A disproportionate part of the area is covered by the 1–20-year-old age class, and there is a marked deficiency in the area covered by the 61–80-year-old age class. Management ultimately will eliminate these abnormalities.

In the application of the Swedish method of regulating the cut, a check on the normality of the age class distribution has been developed. The Swedish method assumes that the theoretical normal forest should have one-sixteenth of its volume in stands between zero and one-quarter of the rotation age, one-half of its volume between one-quarter and three-quarters of the rotation age, and seven-sixteenths of its volume in stands over three-quarters of the rotation age. Table 30 gives the percentage distribution of the volume in the forest in these three age classes.

[2] Expressed in formula form:

$$\text{Annual cut} = \frac{V_1 + V_2 + \frac{V_3}{2}}{X}$$

where V_1 = volume of mature timber
V_2 = volume of overmature timber
V_3 = volume of middle-aged timber
X = number of years in ⅓ the rotation.

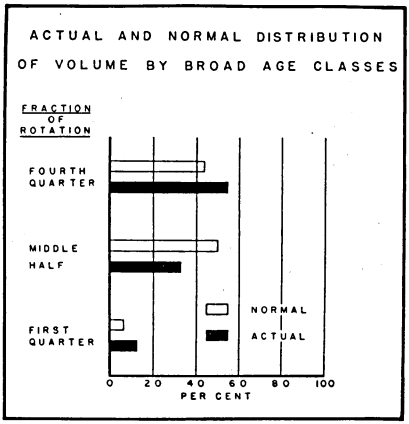

Fig. 46. Actual and Normal Distribution of Volume by Broad Age Classes

The actual distribution of the volume by broad age classes is abnormal. There is a marked deficiency in the volume of the age classes making up the middle half of the rotations proposed. Forest management ultimately will bring about a close agreement in the actual and the normal distribution of volume in these broad age classes.

There is an excess in the first and last quarter of the rotation age witlr a corresponding deficit in the middle-aged quarters. Comparing the average for all types with the normal, there is double the volume that there should be in the stands under one-quarter of the rotation age, one-third less than normal in the middle quarters of the rotation age, and one-fourth too much in the last quarter of the rotation age. This substantiates the statement made previously that there is a surplus of volume in the younger and older age classes in the forest.

According to Heyer's modification of the Austrian method,[3] the annual cut is equal to the difference between the actual and the normal growing stock, divided by the number of years within which the forest is to be brought to normal, plus the mean annual growth.

The normal growing stock is assumed to be equal to one-half the rotation times the annual increment. The deficit or excess indicated by this calculation may be distributed over a shorter or longer period, depending upon the dictates of good silviculture and good business management. The number of years must be made to fit the needs of each particular forest property. The cut, when this period is assumed to be equal to half the rotation age, is shown in Table 29. This method is used here merely to check the Swedish method.

The estimated annual cut by the Swedish method is 48,100 cubic feet, of which about 17,100 cubic feet (= 100,000 feet B.M.) may be sawlogs. The Austrian method indicates an annual cut of 49,800 cubic feet, of which about 15,500 cubic feet (= 95,000 feet B.M.) may be

[3] In formula form it is usually written:

$$\text{Annual cut} = \frac{V\text{-}nV}{x} + i \quad \text{where}$$

i = the mean annual growth
V = the actual growing stock
nV = the normal growing stock, and
x = the number of years within which the forest is to be brought into normal condition.

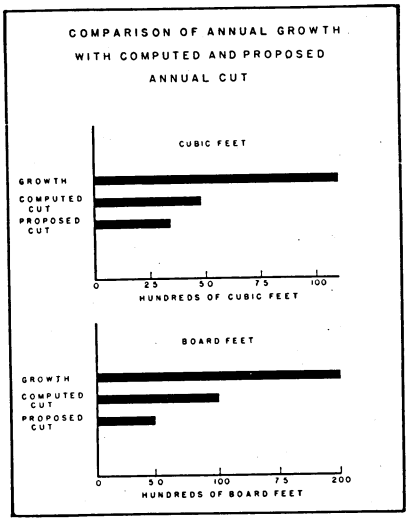

Fig. 47. Comparison of Annual Growth with Computed and Proposed Annual Cut

The actual current growth of the forest greatly exceeds both the calculated and the proposed annual cut. There is a marked deficiency in the area and volume of the middle-aged classes. This deficiency will be rapidly made up by restricting the annual cut to the relatively small volume proposed.

sawlogs. The results of the two methods are practically the same. These calculations show that the annual cut, until the date of the next revision of this plan, should not exceed 48,000 cubic feet, of which about 16,500 cubic feet (= 100,000 feet B.M.) may be sawlogs. In each case, however, the cut amounts to only about one-half of the actual annual growth of the forest and therefore provides for the gradual increase of the actual volume of the forest. This figure could, in case of emergency, be considerably exceeded without danger to the forest. In addition, the dead and dying timber may be salvaged in the virgin stand known as "Camp 8."

In Figure 45 a graphic comparison of actual with normal areas of age classes is made. Figure 46 compares the actual and normal distribution of volume by broad age classes, and Figure 47 compares the annual growth with the computed and proposed annual cut.

Amount and distribution of actual cut for the 1930-1939 period.— The preceding calculations of allowable annual cut are based on the policy of bringing about a normal distribution of age classes in half a rotation. This figure was used because that period seemed better suited to the practice of the private owner who might be unwilling to reduce his present profits enough to accomplish it in a shorter time. He may choose the half rotation period and still feel that he is engaged in an acceptable forestry practice.

However, for various reasons, the University is anxious to establish a sustained yield in a shorter period. Therefore the actual cut allowed for the next 10-year period is reduced far below the cut allowed by the calculations.

Considering both the silvicultural condition of the forest and the local markets, the major part of the cut during the 1930-1939 period will be restricted to one mature and three overmature stands of jack pine. These stands contain approximately 470,000 feet B.M. (about 80,000 cubic feet). In addition, about 60,000 feet B.M. of dying jack pine in

the "Camp 8" stand, and approximately 80,000 cubic feet (about 925 cords) of pulpwood, box bolts, firewood, etc., from the aspen, spruce, balsam, tamarack, and the mixed conifers and hardwood types will be cut during this same period. The cordwood cuttings in these types will be made as, and when, silviculture dictates, provided a market can be found for the products. Marketing conditions in Cloquet during the 1930-1939 period may strongly suggest the cutting of additional amounts of jack pine. If advisable to do so, an additional amount of fuel wood, pulp, and box bolts, not to exceed 200 cords, (18,000 cubic feet) may be cut annually in the form of thinnings and improvement cuttings. Most of it should be from the aspen, jack pine, and mixed conifer and hardwood types.

DETAILED CUTTING PLAN[4]

The cut for the 10-year period, 1930-1939, will be distributed as follows:

1930-31

In Compartments 35 and 40, six acres of decadent 81- to 100-year-old jack pine, which has been estimated to contain approximately 30,000 board feet. Dense white pine reproduction, varying from 3 feet in height to 4 inches D.B.H. is already established under this stand. There are 145 white pine 2 inches D.B.H. and over per acre in addition to a sprinkling of aspen, birch, balsam, and spruce. In view of the care necessary in logging and its relatively remote location, it is felt that this is a sufficient volume to cut during the first season during which the management plan is in operation.

1931-32

In Compartments 22, 23, 24, 28, and 29, a stand of 100-year-old jack pine, a stand of 100-year-old Norway pine, and a stand of 75-year-old jack pine.

It is proposed to clear-cut the 100-year-old jack pine and leave any white or Norway pine, cut the jack pine from the stand of 100-year-old

[4] Circumstances have made it impossible to carry out the foregoing proposed cutting plan. The cut for 1930-31, however, was carried out as planned, but during the periods 1931-32 and 1932-33 nothing was cut because of the drop in the prices of forest products. The actual quantity of forest products cut from the Cloquet Forest is as follows:

1930-31	44,000 board feet plus	58 cords
1933-34	24,000 board feet plus	407 cords
1934-35	20,000 board feet plus	493 cords

Altho the actual cut for 1933-34 and 1934-35 exceeds the proposed cut for these years, the forest has not been over-cut because nothing was cut in the two preceding periods. Furthermore, this material had to be salvaged, or it would have been a total loss.

Part of the man power of a C. C. C. camp near the forest was made available in 1933 through the cooperation of the State Forest Service. This made it possible to make thinnings and improvement cuttings, and to salvage wind-thrown and sleet-damaged timber, which increased the cut for the 1933 to 1935 period over the proposed cut.

Norway, and make a partial cutting in the 75-year-old jack pine. Over most of these areas there is a good stand of advance reproduction.

About 50 acres, which should yield a volume of 61,000 board feet of jack pine, will be cut.

1932-34

In Compartments 48, 49, and 51, a stand of mixed conifers and hardwoods. The conifers are mature and overmature jack and Norway pine. The hardwoods are 21- to 40-year-old aspen and birch. Overmature jack pine and the defective Norway pine should be cut. As there is much brush present on the area, an attempt will be made to cut and tear up as much of it as possible to favor natural seeding. Some planting on the area may be necessary.

Fig. 48. Advanced Mixed Norway, Jack, Birch, and Aspen Reproduction Under an Open, Mature Stand of Norway and Jack Pine
This stand is selected for cutting during the next 10 years.

This involves cutting over of 58 acres, which should yield a volume of 156,000 board feet of jack pine and an undetermined amount of Norway and white pine.

1934-35

A stand of scattered overmature Norway pine located in Compartments 8 and 9 under which a dense stand of Norway, white, and jack pine, and aspen and birch reproduction is already established. The overhead stand should be removed before the reproduction becomes large enough to suffer during the logging.

This involves cutting over about 12 acres, which will yield a volume of 23,000 feet of Norway pine and 4,500 feet of jack pine.

1935-37

Two stands of jack pine 41 to 60 years old in Compartments 2, 3, 7, and 8. A modified shelterwood system whereby approximately three-fourths of the volume will be removed is recommended for these stands. This will necessitate cutting over approximately 34 acres, yielding 119,000 board feet of jack pine.

Fig. 49. Sixty-Year-Old Jack Pine, Averaging About 20 Cords per Acre
Since this stand is mature, it will be cut during the 1930-1939 period.

1937-39

In Compartments 18, 33, 34, 41, and 42 a stand of 40- to 60-year-old jack pine. It is quite uniform in character, fairly dense and free from underbrush. Very little reproduction is found in the stand. The stand covers approximately 70 acres and has a volume of 158,000 board feet of jack pine. Its size and uniformity recommend it for experimental methods of cutting. It should be cut, using clear-cutting, strip-cutting, and various types of shelterwood systems to determine the effects of the different methods of natural reproduction.

ESTIMATED RETURNS UNDER SUSTAINED YIELD MANAGEMENT

Many years are required to develop from a wild, unmanaged forest a forest that will produce forest products continuously at its maximum capacity. During the transitional stage, it is necessary to sacrifice some immediate returns in order to insure the largest possible permanent future income from the forest. Because forest management looks toward future production and returns, it is of interest to consider what and how large those returns may be. The future yields in forest products from a forest can be predicted with a fair degree of accuracy. Future economic factors, such as lumber and stumpage prices, and methods of utilization, can not be predicted with any assurance of accuracy. In the discussion which follows, present-day stumpage prices are used to predict future returns.

The problems and difficulties encountered in bringing the Cloquet Forest under forest management will also be encountered, to a greater or lesser degree, in any or all attempts to develop well-managed forests in the cut-over region. Above all, a period of small returns must be expected. For example, the Cloquet Forest is now growing at an estimated rate of 120,000 cubic feet per year, but the allowable annual cut for the next 10 years has been calculated to be not in excess of 48,000 cubic feet per year, or 40 per cent of the actual growth. This is necessary in order to build up the actual timber capital to such a point that it will later yield the largest, equal, annual returns. Such a forest is called a "normal" forest.

Long before the forest becomes normal in the matter of age class distribution, the maximum volume production will already have been attained. With good management and good fortune, the maximum volume production of the Cloquet Forest should be reached during the last third of the rotation, or in about 50 years.

Because of the lack of normal yield tables for most of the species in this forest, it is difficult to predict what the probable normal production of the future forest will be. Yield tables are available for jack pine, white pine and aspen, but not for birch, spruce, balsam, tamarack, or cedar. For site qualities such as are found on the Cloquet Forest, the normal yield tables show an annual growth of 0.6 cord per acre for jack pine, 1.1 cords per acre for aspen, and 510 board feet per acre for white pine. The only yield tables available for Norway pine show an annual growth of 230 board feet per acre. In a normal forest, this annual growth would represent the allowable annual cut.

At present the forest consists of eight productive types and four non-productive. As rapidly as conditions permit, and as technic is developed, the non-productive types (muskeg, meadow, upland brush, and lowland brush) will be made productive.

As rapidly as can be done naturally, the nine existing types will be converted to four types: Norway pine, white pine, jack pine, and the swamp type, which will undoubtedly be predominantly spruce. These types, of course, will not be pure. There will be a sufficient mixture of other conifers and hardwoods to insure healthy soil conditions.

The selection of these types has been based on a physical analysis of the soil rather than on economic considerations. The excellent markets for all materials makes it possible to give primary consideration to the physical factors. The soil survey shows approximately 1,200 acres best suited for growing Norway pine, 560 acres for white pine, 160 acres for jack pine, and 1,056 acres of swamp for spruce.

If the growth figures previously given are applied to the areas of the probable future types, and if an annual growth of 0.25 cord per acre per year be assumed for the swamp type, the probable future yield of the forest may be calculated. If, in addition, present-day stumpage and delivered log prices be applied to the calculated yields, an approximation may be had of the future gross and net returns from the forest.

In computing the possible future returns from the forest, a stumpage price of $12 per thousand is assumed for white and Norway pine, $2 per cord for jack pine, and $4 per cord for spruce. The gross returns are estimated as $28 per thousand for white and Norway pine sawlogs, $7 per cord for jack pine, and $10 per cord for spruce delivered at the mill. The possible net returns, including the stumpage value, are computed by deducting the average cost of logging and delivering the products to the mill.

The probable future income from the Cloquet Forest is given in Table 31. It is estimated that the probable stumpage value of the annual cut will approximate $8,000; the probable gross returns from the annual cut will approximate $19,000, and the probable net returns, computed as previously described, approximately $12,000.

A comparison of the future returns with the present income from the forest is interesting. The present gross returns, if the allowable annual cut is all taken, will amount to approximately $3,000, probably less than one-sixth of the possible future gross income 50 years hence. It appears to be good business policy to sacrifice some immediate income to provide a larger continuous future income.

These figures of future yield are believed to be conservative and do not tell the entire story. The yield for Norway pine, altho taken from the best available yield tables, is undoubtedly low. Intensive forestry, such as is possible on the Cloquet Forest, will increase the quality and quantity of products. Proper silviculture and planting will keep every acre fully stocked. Judicious thinnings will help to maintain the maxi-

mum rate of growth, improve the quality of the product, and will yield a considerable volume of material. Efficient protection will reduce the loss from fire, insects, and diseases.

Computed without these possible increases, the probable return is $4.25 per acre per year. This still represents an attractive investment. It must be remembered, however, that this is a public forest and therefore pays no taxes. In most other respects it is like any other forest property. The available markets, however, give it a decided advantage over many other forests in the region. They make possible at the present time the practice of intensive forestry which can not be practiced on much of the forest land in the region for 50 years to come.

AREA, STOCK, AND GROWTH TABLES

Table 1.—Forest Type Areas, Cloquet Forest Experiment Station, 1929

Forest type	Area, acres	Per cent	
		Upland area	Total area
Upland types			
Productive			
Mixed conifers and hardwoods	865.8	45.1	29.3
Jack pine	650.8	33.9	22.0
Aspen	177.0	9.2	6.0
Norway pine	50.5	2.6	1.7
Norway and white pine	17.5	0.9	0.6
Non-productive			
Cleared	66.8	3.5	2.3
Administrative	39.2	2.0	1.3
Upland brush	3.0	0.2	0.1
Scenic Forest	48.7	2.6	1.6
Total and per cent	1,919.3	100.0	64.9
Lowland types			
Productive			
Spruce	562.4	54.4	19.1
Tamarack	214.6	20.7	7.3
Mixed conifers and hardwood swamp	71.5	6.9	2.4
Non-productive			
Meadow	64.8	6.3	2.2
Lowland brush	63.8	6.2	2.2
Muskeg	56.9	5.5	1.9
Total and per cent	1,034.0	100.0	35.1
Total area	2,953.3		
Total productive	2,658.8		90.0
Total non-productive	294.5		10.0

Table 2.—Area of Age Classes by Forest Types

Forest type	Age class																Total	
	0		1–20		21–40		41–60		61–80		81–100		100 +		All-aged			
	Acres	Per cent*	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent	Acres	Per cent
Upland types																		
Mixed conifer and hardwood	.....	.....	546.3	63.1	136.8	15.8	12.1	1.4	.....	.....	60.6	7.0	.....	.....	110.0	12.7	865.8	45.1
Jack pine	.....	.....	112.4	17.3	248.0	38.1	265.9	40.9	16.3	2.5	6.9	1.0	1.3	0.2	.....	.....	650.8	33.9
Aspen	.....	.....	79.3	44.8	97.7	55.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	177.0	9.2
Norway pine	.....	.....	20.0	39.6	.....	.....	.....	.....	.....	.....	.....	.....	30.5	60.4	.....	.....	50.5	2.6
Norway and white pine	.....	.....	6.4	36.6	.....	.....	.....	.....	.....	.....	.....	.....	11.1	63.4	.....	.....	17.5	0.9
Non-productive	109.0	100.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	109.0	5.7
Scenic forest	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	48.7	100.0	.....	.....	48.7	2.6
Total upland	109.0	5.7	764.4	39.8	482.5	25.1	278.0	14.5	16.3	0.9	67.5	3.5	91.6	4.8	110.0	5.7	1,919.3	100.0
Lowland types																		
Spruce	.....	.....	132.2	23.5	66.3	11.8	14.0	2.5	.....	.....	5.5	1.0	.....	.....	344.4	61.2	562.4	54.4
Tamarack	.....	.....	.....	.....	19.5	9.1	195.1	90.9	.....	.....	.....	.....	.....	.....	.....	.....	214.6	20.7
Mixed conifer and hardwood swamp	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	71.5	100.0	71.5	6.9
Non-productive	185.5	100.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	185.5	18.0
Total lowland	185.5	18.0	132.2	12.8	85.8	8.3	209.1	20.2	.....	.....	5.5	0.5	.....	.....	415.9	40.2	1,034.0	100.0
Total area	294.5	10.0	896.6	30.2	568.3	19.2	487.1	16.5	16.3	0.6	73.0	2.5	91.6	3.1	525.9	17.9	2,953.3	100.0

* Per cent of type area.

Table 3.—Volume of Standing Timber by Species, 1929

Species	Board feet	Per cent of total	Cords	Per cent of total	Cubic feet	Per cent of total
Aspen	.....	.....	1,500	9.2	105,000	6.0
Birch	.....	.....	1,100	6.8	100,000	5.7
Cedar	.....	.....	200	1.2	20,000	1.1
Jack pine	1,930,000	60.3	10,200	62.6	920,000	52.6
Norway pine	1,100,000	34.4	.....	.....	280,000	16.0
Spruce and balsam	.....	.....	2,500	15.3	225,000	12.9
Tamarack	50,000	1.6	800	4.9	70,000	4.0
White pine	120,000	3.7	.....	.....	30,000	1.7
Total	3,200,000	100.0	16,300	100.0	1,750,000	100.0

Exclusive of timber on Scenic Forest at Camp No. 8.

The volume in cords was obtained by converting the cubic-foot volume to cords by means of converting factors.

The volume in cubic feet is the volume of all trees four inches in diameter and over, including trees suitable for sawtimber.

These totals do not agree with the sums of the volumes from the tables for the types because the Camp No. 8 stand volumes have not been deducted from the individual tables.

Table 4.—Total Volumes by Forest Types and Age Classes, Excluding Scenic Forest

Type	Unit of measure	Age class 1–20	21–40	41–60	61–80	81–100	100+	All-aged	Total volume
Aspen	Board feet	.....	10,000	.....	.....	.....	.....	.....	10,000
	Cords	189	174	.....	.....	.....	.....	.....	363
	Cubic feet	14,200	14,200	.....	.....	.....	.....	.....	28,400
Jack pine	Board feet*	35,000	410,000	1,011,000	89,000	33,000	11,000	.....	1,589,000
	Cords	285	2,598	4,772	299	105	29	.....	8,088
	Cubic feet	30,500	263,700	451,900	29,200	9,800	3,200	.....	788,300
Mixed conifer and hardwoods	Board feet*	234,000	233,000	14,000	.....	228,000	.....	345,000	1,054,000
	Cords	1,577	794	109	.....	672	.....	906	4,058
	Cubic feet	169,100	97,500	9,300	.....	81,700	.....	135,200	492,800
Mixed conifer and hardwood swamp	Board feet	.....	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	.....	.....	.....	.....	374	374
	Cubic feet	.....	.....	.....	.....	.....	.....	33,700	33,700
Mixed Norway and white pine	Board feet	.....	.....	.....	.....	.....	174,000	.....	174,000
	Cords	.....	.....	.....	.....	.....	79	.....	79
	Cubic feet	.....	.....	.....	.....	.....	45,700	.....	45,700
Norway pine	Board feet	.....	.....	.....	.....	.....	310,000	.....	310,000
	Cords	50	.....	.....	.....	.....	93	.....	143
	Cubic feet	4,600	.....	.....	.....	.....	67,500	.....	72,100
Spruce	Board feet	.....	.....	.....	.....	.....	.....	38,000	38,000
	Cords	74	329	150	.....	68	.....	1,898	2,519
	Cubic feet	6,700	29,500	13,500	.....	6,100	.....	169,400	225,200
Tamarack	Board feet	.....	2,000	23,000	.....	.....	.....	.....	25,000
	Cords	.....	59	592	.....	.....	.....	.....	651
	Cubic feet	.....	5,300	53,700	.....	.....	.....	.....	59,000
Total	Board feet	269,000	655,000	1,048,000	89,000	261,000	495,000	383,000	3,200,000
	Cords	2,175	3,954	5,623	299	845	201	3,178	16,275
	Cubic feet	225,100	410,200	528,400	29,200	97,600	116,400	338,300	1,745,200

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

* Volume of merchantable-sized trees found scattered over the 1–20-year age classes in these types.

Grand totals rounded off to nearest 1,000 bd. ft. and 100 cu. ft.

Table 5.—Total Volume of Jack Pine Type by Species and Age Classes

Species	Unit of measure	Total volume by age classes						Total volume
		1–20	21–40	41–60	61–80	81–100	100	
Aspen	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	30	23	119	.....	3	.....	175
	Cubic feet	2,100	1,600	8,300	.....	200	.....	12,200
Birch	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	8	17	56	2	1	.....	84
	Cubic feet	700	1,500	5,000	200	100	.....	7,500
Jack pine	Board feet	24,000*	333,000	923,000	83,000	33,000	9,000	1,405,000
	Cords	247	2,557	4,550	294	101	29	7,778
	Cubic feet	22,200	230,100	409,900	26,500	9,100	2,600	700,400
Norway pine	Board feet	11,000*	76,000	85,000	6,000	.....	2,000	180,000
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	5,400	30,000	23,400	2,200	.....	600	61,600
Spruce	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	1	31	3	.....	.....	35
	Cubic feet	.....	100	2,800	300	.....	.....	3,200
Tamarack	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	16	.....	.....	.....	16
	Cubic feet	.....	.....	1,400	.....	.....	.....	1,400
White pine	Board feet	.....	1,000	3,000	.....	.....	.....	4,000
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	100	400	1,100	.....	400	.....	2,000
Total volume	Board feet	35,000	410,000	1,011,000	89,000	33,000	11,000	1,589,000
	Cords	285	2,598	4,772	299	105	29	8,088
	Cubic feet	30,500	263,700	451,900	29,200	9,800	3,200	788,300

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

* Volume of merchantable-sized trees scattered over these areas.

Table 6.—Volume Per Acre of Jack Pine Type by Species and Age Classes

Species	Unit of measure	Volume per acre by age classes						Weighted average per acre
		1-20	21-40	41-60	61-80	81-100	100	
Aspen	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.3	0.1	0.4	.....	0.4	.....	0.3
	Cubic feet	20	10	30	.....	30	.....	20
Birch	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.1	0.1	0.2	0.1	0.2	0.3	0.1
	Cubic feet	10	10	20	10	20	30	10
Jack pine	Board feet	200	1,350	3,450	5,100	4,850	6,700	2,150
	Cords	2.2	10.3	17.1	18.1	14.8	22.0	12
	Cubic feet	200	930	1,540	1,630	1,330	1,980	1,080
Norway pine	Board feet	100	300	300	400	.....	1,450	300
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	50	120	90	140	.....	430	90
Spruce	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	0.1	0.2	.....	.....	*
	Cubic feet	.....	.....	10	20	.....	.....	*
White pine	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	.....	.....	.....	.....	60	.....	*
Total volume per acre	Board feet	300	1,650	3,750	5,500	4,850	8,150	2,450
	Cords	2.6	10.5	17.8	18.4	15.4	22.3	12.4
	Cubic feet	280	1,070	1,690	1,800	1,440	2,440	1,200

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule, of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

* Reduced to zero when rounded off.

Table 7.—Volume of Norway Pine Type by Species and Age Classes

Species	Unit of measure	Volume by age classes				Total	Per acre
		1–20		100+			
		Total	Per acre	Total	Per acre		
Aspen	Board feet	.....	.....	.....	.....	.....	.....
	Cords	4	0.1	.....	.....	4	*
	Cubic feet	300	10	.....	.....	300	*
Birch	Board feet	.....	.....	.....	.....	.....	.....
	Cords	4	0.2	9	0.1	13	0.1
	Cubic feet	400	20	800	10	1,200	10
Jack pine	Board feet	.....	.....	52,000	650	52,000	550
	Cords	42	2.1	172	2.2	214	2.4
	Cubic feet	3,800	190	15,500	200	19,300	190
Norway pine	Board feet	.....	.....	936,000	11,800	936,000	9,450
	Cords	.....	.....	.....	.....	.....	.....
	Cubic feet	100	10	205,000	2,590	205,100	2,070
Spruce	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	2	.....	2	*
	Cubic feet	.....	.....	200	.....	200	*
White pine	Board feet	.....	.....	39,000	500	39,000	400
	Cords	.....	.....	.....	.....	.....	.....
	Cubic feet	.....	.....	9,400	120	9,400	90
Total and average	Board feet	.....	.....	1,027,000	12,950	1,027,000	10,350
	Cords	50	2.4	183	2.3	233	2.5
	Cubic feet	4,600	230	230,900	2,930	235,500	2,380

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

Inclusive of timber on Scenic Forest Camp No. 8.

* Reduced to zero when rounded off.

Table 8.—Volume of Mixed Norway and White Pine Type by Species and Age Classes

Species	Unit of measure	Volume of age classes 100+ Total	Volume of age classes 100+ Per acre
Aspen	Board feet	.....	.....
	Cords	23	2.1
	Cubic feet	1,600	150
Balsam	Board feet	.....	.....
	Cords	7	0.7
	Cubic feet	600	60
Birch	Board feet	.....	.....
	Cords	21	1.9
	Cubic feet	1,900	170
Jack pine	Board feet	4,000	350
	Cords	12	1.1
	Cubic feet	1,100	100
Norway pine	Board feet	119,000	10,700
	Cords	.....	.....
	Cubic feet	26,700	2,400
White pine	Board feet	51,000	4,600
	Cords	.....	.....
	Cubic feet	12,400	1,120
Spruce	Board feet	.....	.....
	Cords	16	1.3
	Cubic feet	1,400	120
Total and average	Board feet	174,000	15,650
	Cords	79	7.1
	Cubic feet	45,700	4,120

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

Table 9.—Volume of Mixed Conifer and Hardwood Type by Species and Age Classes

Species	Unit of measure	Volume of age classes						Total volume
		1–20	21–40	41–60	61–80	81–100	All-aged	
Aspen	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	408	196	26	.....	39	233	902
	Cubic feet	28,600	13,700	1,800	.....	2,700	16,300	63,100
Balsam	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	62	32	.....	.....	42	23	159
	Cubic feet	5,600	2,900	.....	.....	3,800	2,100	14,400
Birch	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	179	52	.....	.....	167	168	566
	Cubic feet	16,100	4,700	.....	.....	15,000	15,100	50,900
Jack pine	Board feet	149,000*	111,000	14,000	.....	119,000	91,000	484,000
	Cords	910	500	83	.....	368	338	2,199
	Cubic feet	81,900	45,000	7,500	.....	33,100	30,400	197,900
Norway pine	Board feet	82,000*	113,000	.....	.....	92,000	238,000	525,000
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	33,700	27,600	.....	.....	18,100	54,500	133,900
Spruce	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	17	11	.....	.....	53	143	224
	Cubic feet	1,500	1,000	.....	.....	4,800	12,900	20,200
Tamarack	Board feet	.....	1,000	.....	.....	1,000	.....	2,000
	Cords	1	3	.....	.....	3	1	8
	Cubic feet	100	300	.....	.....	300	100	800
White pine	Board feet	3,000	8,000	.....	.....	16,000	16,000	43,000
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	1,600	2,300	.....	.....	3,900	3,800	11,600
Total	Board feet	234,000	233,000	14,000	.....	228,000	345,000	1,054,000
	Cords	1,577	794	109	.....	672	906	4,058
	Cubic feet	169,100	97,500	9,300	.....	81,700	135,200	492,800

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

* Volume of merchantable-sized trees scattered over these areas.

Table 10.—Volume Per Acre of Mixed Conifer and Hardwood Type by Species and Age Classes

Species	Unit of measure	Volume per acre by age classes						Weighted average per acre
		1–20	21–40	41–60	61–80	81–100	All-aged	
Aspen	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.74	1.43	2.16	.....	0.66	2.11	1.04
	Cubic feet	50	100	150	.....	50	150	70
Balsam	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.11	0.23	.....	.....	0.70	0.21	0.18
	Cubic feet	10	20	.....	.....	60	20	20
Birch	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.32	0.38	0.02	.....	2.76	1.52	0.66
	Cubic feet	30	30	.....	.....	250	140	60
Jack pine	Board feet	250	800	1,200	.....	1,950	800	550
	Cords	1.67	3.66	6.91	.....	6.08	3.08	2.54
	Cubic feet	150	330	620	.....	550	280	230
Norway pine	Board feet	150	800	.....	.....	1,500	2,150	600
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	60	200	.....	.....	300	500	150
Spruce	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.03	0.09	.....	.....	0.87	1.30	0.26
	Cubic feet	.....	10	.....	.....	80	120	20
Tamarack	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	0.02	.....	.....	0.06	0.01	0.01
	Cubic feet	.....	.....	.....	.....	.....	.....	.....
White pine	Board feet	.....	50	.....	.....	250	150	50
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	.....	20	.....	.....	60	40	10
Total volume per acre	Board feet	400	1,650	1,200	.....	3,700	3,100	1,200
	Cords	2.87	5.81	9.09	.....	11.13	8.23	4.69
	Cubic feet	300	710	770	.....	1,350	1,250	370

Number of cubic feet per cord; aspen 70, all other species 90 cubic feet. Cords computed before cubic feet were rounded off.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

These figures for total volume per acre are based on the total volume for the type and total type area. They do not agree with the species totals because the figures for volume per acre for some species were so small they were dropped when the figures were rounded off.

Table 11.—Volume of Aspen Type by Species and Age Classes

Species	Unit of measure	Volume by age classes				Total	Per acre
		0–20		21–40			
		Total	Per acre	Total	Per acre		
Aspen	Board feet	.....	.....	.....	.....	.....	.....
	Cords	168	2.1	136	1.4	304	1.7
	Cubic feet	11,800	150	9,500	100	21,300	120
Birch	Board feet	.....	.....	.....	.....	.....	.....
	Cords	13	0.2	13	0.1	26	0.1
	Cubic feet	1,200	20	1,200	10	2,400	10
Jack pine	Board feet	.....	.....	4,000	50	4,000	.....
	Cords	8	0.1	25	0.2	33	0.4
	Cubic feet	700	10	2,300	20	3,000	20
Norway pine	Board feet	.....	.....	6,000	50	6,000	50
	Cords	.....	.....	.....	.....	.....	.....
	Cubic feet	500	10	1,200	10	1,700	10
Total and average	Board feet	.....	.....	10,000	100	10,000	50
	Cords	189	2.4	174	1.7	363	2.2
	Cubic feet	14,200	190	14,200	140	28,400	160

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

Table 12.—Total Volume of Spruce Type by Species and Age Classes

Species	Unit of measure	Volume in age classes					Total volume
		1–20	21–40	41–60	81–100	All-aged	
Aspen	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	.....	.....	69	69
	Cubic feet	.....	.....	.....	.....	4,800	4,800
Balsam	Board feet	.....	.....	.....	.....	.....	.....
	Cords	20	146	39	.....	196	401
	Cubic feet	1,800	13,100	3,500	.....	17,600	36,000
Birch	Board feet	.....	.....	.....	.....	.....	.....
	Cords	3	7	39	.....	189	238
	Cubic feet	300	600	3,500	.....	17,000	21,400
Cedar	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	118	42	.....	61	221
	Cubic feet	.....	10,600	3,800	.....	5,500	19,900
Jack pine	Board feet	.....	.....	.....	.....	12,000	12,000
	Cords	.....	.....	.....	.....	51	51
	Cubic feet	.....	.....	.....	.....	4,600	4,600
Spruce	Board feet	.....	.....	.....	.....	.....	.....
	Cords	51	58	30	67	1,102	1,308
	Cubic feet	4,600	5,200	2,700	6,000	99,200	117,700
Tamarack	Board feet	.....	.....	.....	.....	26,000	26,000
	Cords	.....	.....	.....	1	230	231
	Cubic feet	.....	.....	.....	100	20,700	20,800
Total volume	Board feet	.....	.....	.....	.....	38,000	38,000
	Cords	74	329	150	68	1,898	2,519
	Cubic feet	6,700	29,500	13,500	6,100	169,400	225,200

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

Table 13.—Volume Per Acre of Spruce Type by Species and Age Classes

Species	Unit of measure	Volume per acre by age classes					Weighted average per acre
		1–20	21–40	41–60	81–100	All-aged	
Aspen	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	.....	.....	0.1	0.1
	Cubic feet	.....	.....	.....	.....	10	10
Balsam	Board feet	.....	.....	.....	.....	.....	.....
	Cords	0.1	2.2	2.8	.....	0.6	0.7
	Cubic feet	10	200	250	.....	50	60
Birch	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	0.1	2.8	.....	0.6	0.4
	Cubic feet	.....	10	250	.....	50	40
Cedar	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	1.8	3.0	.....	0.2	0.3
	Cubic feet	.....	160	270	.....	20	30
Jack pine	Board feet	.....	.....	.....	.....	50	*
	Cords	.....	.....	.....	.....	0.1	0.1
	Cubic feet	.....	.....	.....	.....	10	10
Spruce	Board feet	.....	.....	.....	.....	.....	.....
	Cords	0.3	0.9	2.2	12.2	3.2	2.3
	Cubic feet	30	80	200	1,100	290	210
Tamarack	Board feet	.....	.....	.....	.....	50	50
	Cords	.....	.....	.....	0.2	0.7	0.4
	Cubic feet	.....	.....	.....	20	60	40
Total volume per acre	Board feet	.....	.....	.....	.....	100	50
	Cords	0.4	5.0	10.8	12.4	5.5	4.4
	Cubic feet	40	450	970	1,120	490	400

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

These figures for total volume per acre are based on the total volume for the type and total type area. They do not agree with the species totals because the figures for volume per acre for some species were so small they were dropped when the figures were rounded off.

* Reduced to zero when rounded off.

Table 14.—Volume of Tamarack Type by Species and Age Classes

Species	Unit of measure	Volume per acre by age classes				Total	Per acre
		21–40		41–60			
		Total	Per acre	Total	Per acre		
Birch	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	11	0.1	11	0.1
	Cubic feet	.....	.....	1,000	.....	1,000	.....
Jack pine	Board feet	2,000	100	1,000	.....	3,000	*
	Cords	16	0.8	2	.....	18	0.1
	Cubic feet	1,400	70	200	.....	1,600	10
Norway pine	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	.....	.....	.....	.....
	Cubic feet	.....	.....	400	.....	400	*
Spruce	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	121	0.7	121	0.6
	Cubic feet	.....	.....	10,900	60	10,900	50
Tamarack	Board feet	.....	.....	22,000	100	22,000	100
	Cords	43	2.2	458	2.3	501	2.3
	Cubic feet	3,900	200	41,200	210	45,100	210
Total and average	Board feet	2,000	100	23,000	100	25,000	100
	Cords	59	3.0	592	3.1	651	3.1
	Cubic feet	5,300	270	53,700	270	59,000	270

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

* Reduced to zero when rounded off.

Table 15.—Volume of All-Aged Mixed Conifer and Hardwood Swamp Type by Species

Species	Unit of measure	Volume	
		Total	Per acre
Aspen	Board feet	.....	.....
	Cords	1	*
	Cubic feet	100	*
Balsam	Board feet	.....	.....
	Cords	121	1.7
	Cubic feet	10,900	150
Birch	Board feet	.....	.....
	Cords	134	1.9
	Cubic feet	12,100	170
Cedar	Board feet	.....	.....
	Cords	26	2.6
	Cubic feet	2,300	30
Spruce	Board feet	.....	.....
	Cords	91	1.2
	Cubic feet	8,200	110
Tamarack	Board feet	.....	.....
	Cords	1	.....
	Cubic feet	100	.....
Total volume	Board feet	.....	.....
	Cords	374	5.2
	Cubic feet	33,700	460

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.
Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.
Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.
Based on 1929 estimate.
These figures for total volume per acre are based on the total volume for the type and total type area. They do not agree with the species totals because the figures for volume per acre for some species were so small they were dropped when the figures were rounded off.
* Reduced to zero when rounded off.

Table 16.—Periodic Annual Volume Growth by Species, 1930-1939

Species	Total growth					
	Board feet	Per cent of total	Cords	Per cent of total	Cubic feet	Per cent of total
Aspen	.....	.....	385	29.9	26,900	22.5
Birch	.....	.....	111	8.6	10,000	8.4
Cedar	.....	.....	12	0.9	1,100	0.9
Jack pine	153,000	77.3	549	42.6	49,400	41.3
Norway pine	37,000	18.7	.....	.....	10,300	8.6
Spruce and balsam	.....	.....	200	15.5	18,000	15.1
Tamarack	5,000	2.5	32	2.5	2,900	2.4
White pine	3,000	1.5	.....	.....	1,000	0.8
Total	198,000	100.0	1,289	100.0	119,600	100.0

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.
Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three inch top diameter of all trees four inches in diameter and larger.
Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.
Based on 1929 estimate.
Exclusive of growth of Scenic Forest at Camp No. 8.
The difference between these totals and those in Table 17 are due to rounding off.

Table 17.—Total Periodic Annual Growth by Forest Types and Age Classes, 1930-1939

Type	Unit of measure	Age class							Total growth
		0-20	21-40	41-60	61-80	81-100	100+	All-aged	
Aspen	Board feet	.....	800	.....	.....	.....	.....	.....	800
	Cords	.....	115.2	.....	.....	.....	.....	.....	115.2
	Cubic feet	.....	8,390	.....	.....	.....	.....	.....	8,390
Jack pine	Board feet*	3,550	60,100	62,300	3,150	350	200	.....	129,650
	Cords	23.2	209.7	164.7	7.5	1.4	0.3	.....	406.8
	Cubic feet	2,370	22,640	15,790	780	260	50	.....	41,890
Mixed conifer and hardwoods	Board feet*	11,800	15,000	2,950	.....	6,800	.....	14,750	51,500
	Cords	342.0	91.0	15.5	.....	27.3	.....	52.7	528.5
	Cubic feet	27,940	8,280	1,260	.....	3,080	.....	5,670	46,230
Mixed conifer and hardwood swamp	Board feet	.....	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	.....	.....	.....	.....	25.7	25.7
	Cubic feet	.....	.....	.....	.....	.....	.....	2,320	2,320
Mixed Norway and white pine	Board feet	.....	.....	.....	.....	.....	3,200	.....	3,200
	Cords	.....	.....	.....	.....	.....	2.6	.....	2.6
	Cubic feet	.....	.....	.....	.....	.....	850	.....	850
Norway pine	Board feet	.....	.....	.....	.....	.....	6,200	.....	6,200
	Cords	.....	.....	.....	.....	.....	7.2	.....	7.2
	Cubic feet	.....	.....	.....	.....	.....	1,060	.....	1,060
Spruce	Board feet	.....	.....	.....	.....	.....	.....	1,750	1,750
	Cords	4.6	10.4	12.2	.....	4.2	.....	145.7	177.1
	Cubic feet	420	940	1,100	.....	380	.....	13,070	15,910
Tamarack	Board feet	.....	150	3,900	.....	.....	.....	.....	4,050
	Cords	.....	3.8	27.2	.....	.....	.....	.....	31.0
	Cubic feet	.....	350	2,470	.....	.....	.....	.....	2,820
Total	Board feet	15,350	76,250	69,150	3,150	7,150	9,600	16,500	197,000
	Cords	369.8	430.1	219.6	7.5	32.9	10.1	224.1	1,294
	Cubic feet	30,730	40,600	20,620	780	3,720	1,960	21,060	119,500

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

* Volume of merchantable-sized trees scattered over these areas.

Grand totals rounded off to nearest 1,000 bd. ft. and 100 cu. ft.

Table 18.—Periodic Annual Growth of Jack Pine Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class						Total growth
		0–20	21–40	41–60	61–80	81–100	100+	
Aspen	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	3.4	4.9	10	.....	0.4	.....	18.7
	Cubic feet	240	340	700	.....	30	.....	1,310
Birch	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	3.1	2.3	7.9	0.1	0.1	0.1	13.6
	Cubic feet	280	210	710	10	10	10	1,230
Jack pine	Board feet	2,800	54,050	59,700	2,950	350	100	119,950
	Cords	16.7	202.3	143.8	7.3	0.9	0.2	371.2
	Cubic feet	1,500	18,210	12,940	660	80	20	33,410
Norway pine	Board feet	750	6,000	2,600	200	.....	100	9,650
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	340	3,830	1,060	100	.....	20	5,350
Spruce	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	0.2	2.7	0.1	.....	.....	3.0
	Cubic feet	.....	20	240	10	.....	.....	270
Tamarack	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	0.3	.....	.....	.....	0.3
	Cubic feet	.....	.....	30	.....	.....	.....	30
White pine	Board feet	.....	50	.....	.....	.....	.....	50
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	10	30	110	.....	140	.....	290
Total	Board feet	3,550	60,100	62,300	3,150	350	200	129,650
	Cords	23.2	209.7	164.7	7.5	1.4	0.3	406.8
	Cubic feet	2,370	22,640	15,790	780	260	50	41,890

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

Table 19.—Periodic Annual Growth Per Acre of Jack Pine Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class						Weighted average per acre
		0–20	21–40	41–60	61–80	81–100	100+	
Aspen	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.03	0.01	0.04	.....	0.06	.....	0.03
	Cubic feet	2	1	3	.....	4	.....	2
Birch	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.02	0.01	0.03	0.01	0.02	0.06	0.02
	Cubic feet	2	1	3	1	2	5	2
Jack pine	Board feet	25	220	225	180	50	75	195
	Cords	0.14	0.81	0.54	0.44	0.12	0.19	0.56
	Cubic feet	13	73	49	40	11	17	51
Norway pine	Board feet	5	25	10	15	.....	85	15
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	3	15	4	6	.....	15	8
Miscellaneous	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	0.01	0.06	.....	.....	.....
	Cubic feet	.....	.....	1	5	20	.....	1
Total growth	Board feet	30	245	235	195	50	160	210
	Cords	0.19	0.83	0.62	0.51	0.20	0.25	0.61
	Cubic feet	20	90	60	52	37	37	64

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.
Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.
Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.
Based on 1929 estimate.
Miscellaneous: White pine, spruce, and tamarack.

Table 20.—Periodic Growth of Norway Pine Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class	
		100+	
		Total	Per acre
Birch	Board feet	.....	.....
	Cords	1.4	0.02
	Cubic feet	130	2
Jack pine	Board feet	2,200	30
	Cords	5.7	0.07
	Cubic feet	510	6
Norway pine	Board feet	18,050	230
	Cords	.....	.....
	Cubic feet	2,740	35
Spruce	Board feet	.....	.....
	Cords	0.1	*
	Cubic feet	10	*
White pine	Board feet	1,050	15
	Cords	.....	.....
	Cubic feet	170	2
Total growth	Board feet	21,300	275
	Cords	7.2	0.09
	Cubic feet	3,560	45

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.
Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.
Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.
Based on 1929 estimate.
Inclusive of growth of timber on Scenic Forest at Camp No. 8.
* Reduced to zero when rounded off.

Table 21.—Periodic Growth of Mixed Norway and White Pine Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class 100+	
		Total	Per acre
Aspen	Board feet	.....	.....
	Cords	1.0	0.09
	Cubic feet	70	6
Balsam	Board feet	.....	.....
	Cords	0.2	0.02
	Cubic feet	20	2
Birch	Board feet	.....	.....
	Cords	0.9	0.08
	Cubic feet	80	7
Jack pine	Board feet	100	10
	Cords	0.2	0.02
	Cubic feet	20	2
Norway pine	Board feet	2,300	210
	Cords	.....	.....
	Cubic feet	430	39
Spruce	Board feet	.....	.....
	Cords	0.3	0.03
	Cubic feet	30	3
White pine	Board feet	800	75
	Cords	.....	.....
	Cubic feet	200	18
Total growth	Board feet	3,200	295
	Cords	2.6	0.24
	Cubic feet	850	77

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.
Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.
Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.
Based on 1929 estimate.

Table 22.—Periodic Annual Growth of Mixed Conifer and Hardwood Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class						Total
		0–20	21–40	41–60	61–80	81–100	All-aged	
Aspen	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	191.4	40.3	6.6	.....	4.7	20.7	263.7
	Cubic feet	13,400	2,820	460	.....	330	1,450	18,460
Balsam	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	3.3	3.9	.....	.....	4.4	2.4	14.0
	Cubic feet	300	350	.....	.....	400	220	1,270
Birch	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	36.9	9.6	0.3	.....	8.1	11.8	66.7
	Cubic feet	3,320	860	30	.....	730	1,060	6,000
Jack pine	Board feet	8,900	10,700	2,950	.....	4,500	3,900	30,950
	Cords	108.6	35.6	8.6	.....	8.3	9.4	170.5
	Cubic feet	9,770	3,200	770	.....	750	850	15,340
Norway pine	Board feet	2,500	4,150	.....	.....	1,900	10,550	19,100
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	850	870	.....	.....	640	1,240	3,600
Spruce	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	1.7	1.5	.....	.....	1.7	8.3	13.2
	Cubic feet	150	130	.....	.....	150	750	1,180
Tamarack	Board feet	50	50	.....	.....	.....	.....	100
	Cords	0.1	0.1	.....	.....	0.1	0.1	0.4
	Cubic feet	10	10	.....	.....	10	10	40
White pine	Board feet	350	300	.....	.....	400	300	1,350
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	140	40	.....	.....	70	90	340
Total growth	Board feet	11,800	15,200	2,950	.....	6,800	14,750	51,500
	Cords	342.0	91.0	15.5	.....	27.3	52.7	528.5
	Cubic feet	27,940	8,280	1,260	.....	3,080	5,670	46,230

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

Table 23.—Periodic Annual Growth Per Acre of Mixed Conifer and Hardwood Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class						Weighted average per acre
		0–20	21–40	41–60	61–80	81–100	All-aged	
Aspen	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.34	0.30	0.54	.....	0.07	0.19	0.30
	Cubic feet	24	21	38	.....	5	13	21
Birch	Board feet	.....	.....	.....	.....	.....	.....	.....
	Cords	0.07	0.07	0.02	.....	0.13	0.11	0.08
	Cubic feet	6	6	2	.....	12	10	7
Jack pine	Board feet	15	80	245	.....	75	35	35
	Cords	0.20	0.26	0.71	.....	0.13	0.09	0.20
	Cubic feet	18	23	64	.....	12	8	18
Norway pine	Board feet	5	30	.....	.....	30	95	20
	Cords	.....	.....	.....	.....	.....	.....	.....
	Cubic feet	2	6	.....	.....	11	11	4
Miscellaneous	Board feet	.....	.....	.....	.....	5	5	*
	Cords	0.01	0.04	.....	.....	0.10	0.10	0.03
	Cubic feet	1	4	.....	.....	10	10	3
Total growth per acre	Board feet	20	110	245	.....	110	135	55
	Cords	0.62	0.67	1.27	.....	0.43	0.49	0.61
	Cubic feet	51	60	104	.....	50	52	53

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.
Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.
Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.
Based on 1929 estimate.
* Reduced to zero when rounded off.

Table 24.—Periodic Growth of Aspen Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class 21–40		Average for type area
		Total	Per acre	Per acre
Aspen	Board feet	.....	.....	.....
	Cords	99.2	1.42	0.56
	Cubic feet	6,940	71	39
Birch	Board feet	.....	.....	.....
	Cords	13.3	0.13	0.08
	Cubic feet	1,200	12	7
Jack pine	Board feet	700	5	5
	Cords	2.7	0.03	0.01
	Cubic feet	240	2	1
Norway pine	Board feet	100	.....	.....
	Cords	.....	.....	.....
	Cubic feet	10	.....	.....
Total	Board feet	800	5	5
	Cords	115.2	1.58	0.65
	Cubic feet	8,390	85	47

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.
Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.
Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.
Based on 1929 estimate.

Table 25.—Periodic Annual Growth of Spruce Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class					Total
		1–20	21–40	41–60	81–100	All-aged	
Aspen	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	.....	.....	1.9	1.9
	Cubic feet	.....	.....	.....	.....	130	130
Balsam	Board feet	.....	.....	.....	.....	.....	.....
	Cords	1.3	4.1	7.3	.....	21.8	34.5
	Cubic feet	120	370	660	.....	1,960	3,110
Birch	Board feet	.....	.....	.....	.....	.....	.....
	Cords	0.2	0.2	1.3	.....	6.9	8.6
	Cubic feet	20	20	120	.....	620	780
Cedar	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	3.4	2.6	.....	5.0	11.0
	Cubic feet	.....	310	230	.....	450	990
Jack pine	Board feet	.....	.....	.....	.....	500	500
	Cords	.....	.....	.....	.....	1.3	1.3
	Cubic feet	.....	.....	.....	.....	120	120
Spruce	Board feet	.....	.....	.....	.....	.....	.....
	Cords	3.1	2.7	1.0	4.1	98.6	109.5
	Cubic feet	280	240	90	370	8,870	9,850
Tamarack	Board feet	.....	.....	.....	.....	1,250	1,250
	Cords	.....	.....	.....	0.1	10.2	10.3
	Cubic feet	.....	.....	.....	10	920	930
Total growth	Board feet	.....	.....	.....	.....	1,750	1,750
	Cords	4.6	10.4	12.2	4.2	145.7	177.1
	Cubic feet	420	940	1,100	380	13,070	15,910

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

Table 26.—Periodic Annual Growth Per Acre of Spruce Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class					Weighted average per acre
		1–20	21–40	41–60	81–100	All-aged	
Balsam	Board feet	.....	.....	.....	.....	.....	.....
	Cords	0.01	0.07	0.52	.....	0.07	0.07
	Cubic feet	1	6	47	.....	6	6
Cedar	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	0.06	0.18	.....	0.01	0.02
	Cubic feet	.....	5	16	.....	1	2
Spruce	Board feet	.....	.....	.....	.....	.....	.....
	Cords	0.02	0.04	0.07	0.74	0.29	0.20
	Cubic feet	2	4	6	67	26	18
Tamarack	Board feet	.....	.....	.....	.....	5	*
	Cords	.....	.....	.....	0.01	0.03	0.02
	Cubic feet	.....	.....	.....	1	3	2
Miscellaneous	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	.....	.....	0.03	0.02
	Cubic feet	.....	.....	.....	.....	3	2
Total growth per acre	Board feet	.....	.....	.....	.....	5	4
	Cords	0.3	0.17	0.77	0.75	0.43	0.33
	Cubic feet	3	15	69	68	39	30

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.
Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.
Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.
Based on 1929 estimate.
Miscellaneous aspen, birch, and jack pine.
* Reduced to zero when rounded off.

Table 27.—Periodic Growth of Tamarack Type by Species and Age Classes, 1930-1939

Species	Unit of measure	Age class				Total and average	
		21–40		41–60			
		Total	Per acre	Total	Per acre	Total	Per acre
Birch	Board feet	.....	.....	.....	.....	.....	.....
	Cords	.....	.....	0.7	.....	0.7	.....
	Cubic feet	.....	.....	60	.....	60	.....
Jack pine	Board feet	150	10	50	.....	200	.....
	Cords	1.2	0.07	0.7	.....	1.9	0.01
	Cubic feet	110	6	60	.....	170	1
Norway pine	Board feet	.....	.....	150	.....	150	*
	Cords	.....	.....	.....	.....	.....	.....
	Cubic feet	.....	.....	30	.....	30	*
Spruce	Board feet	.....	.....	.....	.....	.....	.....
	Cords	0.3	0.02	7.0	0.03	7.3	0.03
	Cubic feet	30	2	630	3	660	3
Tamarack	Board feet	.....	.....	3,700	20	3,700	15
	Cords	2.3	0.12	18.8	0.10	21.1	0.10
	Cubic feet	210	11	1,690	9	1,900	9
Total growth	Board feet	150	10	3,900	20	4,050	20
	Cords	3.8	0.21	27.2	0.13	31.0	0.04
	Cubic feet	350	19	2,470	12	2,820	14

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.
Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.
Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.
Based on 1929 estimate.
* Reduced to zero when rounded off.

Table 28.—Periodic Growth of All-Aged Mixed Conifer and Hardwood Swamp Type by Species, 1930-1939

Species	Unit of measure	All-aged	
		Total	Per acre
Balsam	Board feet	.....	.....
	Cords	14.3	0.20
	Cubic feet	1,290	18
Birch	Board feet	.....	.....
	Cords	6.0	0.09
	Cubic feet	540	8
Cedar	Board feet	.....	.....
	Cords	1.4	0.02
	Cubic feet	130	2
Spruce	Board feet	.....	.....
	Cords	3.9	0.06
	Cubic feet	350	5
Miscellaneous	Board feet	.....	.....
	Cords	0.1	*
	Cubic feet	10	*
Total growth	Board feet	.....	.....
	Cords	25.7	0.37
	Cubic feet	2,320	33

Number of cubic feet per cord: aspen 70, all other species 90 cubic feet.

Volume in cubic feet and cords is the volume with bark above a one-foot stump to a three-inch top diameter of all trees four inches in diameter and larger.

Volume in board feet is the volume to a six-inch top by the Scribner Decimal C log rule of all trees seven or eight inches in diameter and larger.

Based on 1929 estimate.

* Reduced to zero when rounded off.

Table 29.—Computed Allowable Annual Cut in Cubic Feet

Forest type	Rotation	Periodic annual growth*	Annual cut*	
			Austrian (Heyers)†	Swedish
	years	cu. ft.	cu. ft.	cu. ft.
Mixed conifers and hardwoods (upland)	80	46,200	12,300	8,400
Jack pine	60	41,900	26,300	28,700
Aspen	50	8,400	1,100	600
Norway pine	80	1,100	1,800	2,500
Norway and white pine	80	900	1,100	1,700
Total upland		98,500	42,600	41,900
Spruce	100	15,800	4,400	4,200
Tamarack	80	2,800	1,300	1,100
Mixed conifer and hardwood swamp	80	2,300	1,500	900
Total lowland		20,900	7,200	6,200
Grand total		119,400	49,800	48,100

Computed Allowable Annual Cut in Board Feet

Forest type	Rotation	Periodic annual growth*	Annual cut*	
			Austrian (Heyers)†	Swedish
	years	bd. ft.	bd. ft.	bd. ft.
Mixed conifers and hardwoods (upland)	80	51,500	26,400	21,800
Jack pine	60	129,700	53,000	61,400
Norway pine	80	6,400	7,700	11,400
Norway and white pine	80	3,200	4,400	6,400
Other types		6,600	1,800	1,500
Total		197,400	93,300	102,500

* Excluding the Scenic Forest at Camp No. 8.

† Heyer's variation.

Table 30.—Test by the Swedish Method of the Normality of the Distribution of Volume by Broad Age Classes

Forest type	Rotation	Percentage distribution of total volume in: First quarter of rotation age — Actual	First quarter of rotation age — Difference	Second and third quarters of rotation age — Actual	Second and third quarters of rotation age — Difference	Fourth quarter of rotation age — Actual	Fourth quarter of rotation age — Difference
	years	per cent		per cent		per cent	
Mixed conifers and hardwoods (upland)	80	36.0	+29.75	35.4	−14.6	28.6	−15.15
Jack pine	60	2.9	− 3.35	48.8	− 1.2	48.3	+ 4.55
Aspen	50	31.2	+24.95	62.6	+12.6	6.2	−37.55
Norway pine	80	2.0	− 4.25	.....	−50.0	98.0	+54.25
Norway and white pine	80	.....	− 6.25	.....	−50.0	100.0	+56.25
Spruce	100	10.5	+ 4.25	53.4	+ 3.4	36.1	− 7.65
Tamarack	80	.....	− 6.25	100.0	+50.0	.....	−43.75
Mixed conifers and hardwoods (lowland)	80	6.2	− 0.05	50.0	.....	43.8	− 0.05
Total upland		13.2	+ 6.95	27.3	−22.7	59.5	+15.75
Total lowland		8.4	+ 2.15	61.7	+11.7	29.9	−13.85
Grand total		12.4	+ 6.15	33.0	−17.0	54.6	+10.85
Normal percentage		6.25	.....	50.0	.....	43.75	.....

Table 31.—Probable Future Annual Income From the Cloquet Forest

Species	Predicted: Annual growth or cut	Stumpage value of annual cut	Gross returns from annual cut	Net returns from annual cut
Norway pine	280,000 bd.ft.	$3,400	$7,800	$5,000
White pine	286,000 bd.ft.	3,400	8,200	5,300
Jack pine	96 cords	200	700	300
Spruce	264 cords	1,000	2,600	1,600
Total		$8,000	$19,300	$12,200

APPENDIX

SILVICAL CHARACTERISTICS OF THE IMPORTANT SPECIES IN THE FOREST

Jack Pine

The jack pine *(Pinus banksiana)* is a tree of the lighter, drier soils. Its superiority over the western yellow pine in the plantations in the sand hill regions of Nebraska mark it as one of the most drought-resistant trees in the country. It is capable of growing in coarse sand containing only a small amount of moisture, but is, of course, stunted under such conditions. On gravel soils, such as are usually occupied by Norway pine, it seems to make its best growth.

For the first 20 years it is the fastest growing conifer in the Lake States, with the possible exception of the upland tamarack. On the better soils it is overtaken by white and Norway pine in about 40 years, but has been known to compete successfully with Norway pine for 100 years.

The jack pine is an extremely intolerant tree. Its shade is so light that almost any of our species, with the exception of aspen and tamarack, can grow under it as a second story. The jack pine, itself, however, is never found growing successfully in the shade of any other species. Instances are cited in which jack pine has intruded into dense stands of aspen and brush; but it came into small openings, not as a real understory. It can stand almost any amount of crowding from the side, and therefore often grows in almost unbelievably dense stands; but it soon dies if overtopped.

Under different conditions it may have widely different associates. On the drier locations it is most often found in mixture with Norway pine. Most likely the two start in an open area following a burn. If the stand is dense, the Norway probably forms an understory for the first 20 to 30 years. Soon after that the Norway forges ahead and the jack pine remains only in the openings. All stages of the type's development are found in the forest.

Under a little more favorable moisture conditions, as in the vicinity of swamps, the jack pine often forms a strange mixture with black spruce, always, of course, in the overstory. In drier locations, on coarse sand, it mixes with the scrub oak.

On the driest sands nothing can compete with it. There the jack pine forms pure stands over very large areas.

It is a frequent and prolific seeder. Moreover, it holds its seed in serotinous cones for many years. A few of these cones open every

year, but most of them remain closed until they are subjected to heat or until the tree is felled and the cones are brought within a foot or so of the ground. A bare soil is necessary for the successful establishment of seedlings.

The jack pine has some shortcomings. It is relatively short-lived, seldom exceeding a hundred years of age, is very susceptible to fire and heart rot and to the attack of several injurious insects, the most serious of which is the jack pine saw-fly. The budworm is probably the next.

The Norway Pine

Silviculturally, Norway pine *(Pinus resinosa)* occupies a place midway between jack pine and white pine.

It is not very exacting in its soil requirements. Only the scrub oak is able to follow the jack pine farther out onto the dry, coarse sands than Norway pine, and yet Norway associates with the white pine on very much moister soils containing considerable clay. In the latter situation individuals make their best development, but on the slightly drier, gravelly loam soils it develops best as a stand.

On the dry sands it is at a disadvantage in its competition with the jack pine. Always a slower grower than the jack pine, its growth is still further retarded by lack of water. But it is comparatively long-lived, even in such an unfavorable location, and eventually dominates the jack pine.

On the wetter soils it is subjected to severe competition by white pine and such hardwoods as white birch, white elm, and basswood. The white pine is a slightly faster grower on such soils, and, being more tolerant, it limits the Norway to the openings. In such openings, however, it does very well and continues to hold its place in the association until a ripe old age.

It is on the gravelly loam that it plays its most important part. There it often forms pure stands, usually dense enough to block out jack pine altogether. It cannot, of course, shade out the white pine or the hardwoods, but the soil is a little too light for their successful growth and they are eliminated.

Such pure stands are seldom dense enough to prevent the intrusion of some undergrowth. It may not be able to grow luxuriantly, but it is there—hazel on the drier sites and alder on the wetter ones—and as soon as the overstory is broken it bursts into redoubled vigor and often, by means of sprouts, so completely occupies the ground that it is years before a forest cover can be reestablished. In fact, the domination of large areas of cut-over Norway lands by brush has already created one of the most difficult silvicultural problems of the Lake States.

Unfortunately the Norway pine, unlike the white pine, does not possess the tolerance necessary to reproduce under its own shade, except in very open stands. However, most of the brush plants are also intolerant, and a stand can be opened up enough to establish Norway pine reproduction without encouraging an excessive growth of brush.

The Norway pine has a number of associates. On the drier sands it mingles with jack pine and scrub oak. It can grow on equal terms with them in an open stand, or as an understory. Eventually it works its way through the overstory and dominates the stand. This habit, together with the assistance of fire, is probably responsible for the conversion of many acres of mixed Norway and jack pine to pure stands of Norway pine.

On cut-over and burned-over areas Norway pine is often found as an understory under a stand of aspen and birch. Here also it eventually dominates the overstory and, if there is enough of it, appears eventually as a pure stand.

On the better soils it frequently grows in mixture with white pine and such hardwoods as elm, basswood, white ash, red oak, and red maple. Here, with these more tolerant associates, it is confined to the openings and is completely suppressed if overtopped. In such situations individuals reach their best development.

The Norway pine is not a very prolific seeder. A few cones are produced almost every year, but a heavy seed crop is produced only every three to five years. The seed usually shows a very high percentage of germination (from 80 to 95 per cent). Therefore a good stand of reproduction is usually established after a good seed year, provided a proper seedbed is available.

The Norway pine seedling can not establish itself where the litter is deep. If reproduction is to be successful, the mineral soil must be exposed, or be covered by only a very thin layer of duff. Too little or too much moisture will also be a serious hindrance.

The Norway pine is probably more fire-resistant than any of the other Lake States conifers. The older age classes of white pine and larch may be more resistant, but jack pine, white and black spruce, balsam, white cedar, juniper, and the younger age classes of white pine and tamarack are much more readily killed by fire.

The Norway pine is peculiarly immune to insect and fungus attack. So far no serious pest has arisen to interfere with its growth in this region.

White Pine

White pine *(Pinus strobus)* occurs on a wide range of soils in the different parts of the country. In the Lake States it seems to demand at least a trace of clay in the soil. The water-holding capacity of the

soil is apparently the limiting factor, since it occurs on lighter soils where the rainfall is heavier. It attains its best development on the deep, rich soils, in mixture with the hardwoods.

For the first few years white pine grows slowly. The growth rate usually begins to accelerate at about the fifth to the tenth year. On the better soils the increase comes earlier. Under favorable conditions, it grows more rapidly than any other eastern conifer with the possible exception of upland larch. It grows persistently and lives to a great age.

As has been mentioned above, the white pine frequently is found in pure stands in old fields. These stands are often very dense. As long as this density remains unbroken nothing comes up under the stand. Dead needles often form the only ground cover.

The tolerance of white pine is still the subject of much discussion. It is fairly well agreed, however, that it is of medium tolerance. Probably its relationship to other species brings out its tolerance best.

The fact that the white pine is never found in a healthy condition under spruce or balsam, or under the tolerant hardwoods, while these species are able to establish their reproduction fairly well under the average stand of white pine, shows very clearly their relative ability to withstand shade. White pine is found over them as a dominant species, or even with them as a competitor in rate of growth, but never under them.

It grows with hemlock, white spruce, sugar maple, beech, basswood, elm, and yellow birch on the better soils, but it comes in only in the openings, and if those openings close before the pine gets its head through the canopy, it is squeezed out.

The white pine's relation to the fire type is no less clear. Even under the thinner stands of aspen, birch, and cherry it seeds in, grows there strongly and persistently, and usually at the end of 30 to 40 years overtops them. Then the fire trees, clearly less tolerant than the pine, are quickly choked out—first the cherry, then the aspen, and lastly, often considerably later, the birch.

With the pitch pine on the drier soils in the East, and with the Norway and jack pine in the West, the story is much the same.

In the Lake States and in southern New England it mixes in the same way with elm, basswood, white ash, and black cherry.

The white pine sometimes begins to produce seed as early as the twentieth year, but commonly from the fortieth to the sixtieth year. Up to a very old age, it continues to produce at intervals of three to seven years. The germination percentage varies from 50 to 85 per cent. The seed is somewhat larger than Norway, but has a good-sized wing and can be depended upon to spread in sufficient quantity for 100 to 200 feet from the seed tree.

The seed must reach the mineral soil for good germination. The bare ground or short, thin grass forms the best seedbed. This accounts for the readiness with which it comes up in dense, pure stands in old fields in New England. Altho it germinates in openings in the hardwood forest, it is often smothered by the falling leaves, or dies after the first year for lack of light and moisture.

As a young tree, when the bark is thin, it is easily killed by fire, but in the older stages when the bark has thickened, it can withstand a very hot surface fire.

The white pine weevil is its worst insect enemy in the younger stages, and the white pine blister rust is its most serious disease at any age. It is, moreover, quite susceptible to heart rot, and for this reason the gross volume of old stands usually must be heavily discounted.

Aspen and Birch

Aspen *(Populus tremuloides)* and white birch *(Betula papprifera)* occupy much the same range in Minnesota and are often found in mixture. Since they are quite similar in many of their characteristics, they are discussed together. They are both best suited to a seedbed of mineral soil and require plenty of light for germination. Both are very prolific seeders, and seeds of both are light enough to be carried by the wind for considerable distances. Neither is particular about the soil on which it grows. The birch is a little the more tolerant of the two, but neither of them can stand any shade from above. Birch sprouts abundantly from the stump, and aspen suckers freely from the roots. Both are fairly rapid growers. Any slight advantage which the aspen may have in this respect is counterbalanced by the slightly greater tolerance of the birch.

These characteristics make them well fitted to occupy quickly land which has been cleared by fire or logging, and to form there what is commonly known as the "fire type." These qualifications also fit them to occupy any small openings in the forest, and they are, for that reason, found associated with almost all the species growing within their range.

Both species are readily killed to the ground by even a light fire, but both are quickly replaced by fast-growing sprouts or suckers. In the open the birch is severely attacked by the bronze birch borer, but neither has any serious insect enemies in a dense stand.

Birch sprouts are quite often infected with heart rot from the decaying stumps, and aspen, whether seedling or sucker, usually begins to show decay at an early age. This is so serious in the case of the aspen that there is little use in trying to grow it to commercial size except on very good soil.

Balsam Fir

The balsam fir *(Abies balsamea)* is the most tolerant conifer native to Minnesota. Altho it is capable of forming an understory under most of the other species, its distribution is somewhat restricted by its need for a moist soil. This requirement confines it to the moist ground immediately surrounding swamps, or other unusually wet areas. Occasionally it invades the shallow peat swamps, but more often it is found in a rather narrow border around them. Sometimes it is mixed with other moisture-loving species such as black spruce, white and yellow birch, and black ash, but more often it is in pure stand.

Every three to five years it produces a fair crop of seed, which seem to germinate readily in a seedbed of moss or litter.

The balsam fir grows rapidly and is capable of forming a stand so dense that nothing can grow beneath it.

The Black Spruce

The black spruce *(Picea mariana)* is usually found in peat swamps. It usually grows in pure stands, often exceedingly dense, but is sometimes found in mixture with tamarack, and even with white cedar and balsam. In the swamp it grows for the most part in acidic sphagnum moss; on the borders of the swamp it seems able to thrive on any soil it finds there. In the bog locations its growth is unbelievably slow, but on higher ground its growth compares favorably with the white spruce. Even on dry sand it frequently forms an understory under jack pine.

From a very early age it is a prolific seeder and retains its seed in serotinous cones. The seedlings seem capable of establishing themselves either on mineral soil or in deep duff. In the sphagnum bogs the seed sometimes germinates well in the peat, but a considerable part of the reproduction in such locations is by layering.

Next to hemlock and balsam, it is the most tolerant conifer in the East. It often grows in such dense stands that nothing, except moss, grows beneath it.

A number of factors make black spruce very susceptible to damage from fire: its shallow root system, thin bark, inflammable needles, and dead limbs persisting clear to the ground. It is killed by a very light ground fire, and is often the cause of a crown fire.

A rather flat root system makes it subject to wind-throw in the soft bogs, but not nearly so much so as the red spruce.

Tamarack

The range and habitat of tamarack *(Larix laricina)* are very much the same as those of the black spruce. It is the most intolerant tree in the northeastern United States, but the density of some of the pure stands

indicates that it can stand considerable crowding if not over-topped. Because of its intolerance, tamarack makes its best growth in pure, even-aged stands, and for this reason usually dominates other species in all mixtures. This type, however, may contain from 1 to 20 per cent of balsam and black spruce, the balsam usually coming in on the shallow peat near the edges of the swamps.

In its usual habitat, the peat, often many feet deep, is seldom shallower than a foot. If it is shallower, there is usually a mixture of tamarack and balsam. In such situations the growth of tamarack is usually very slow. Systematic experiments and chance road ditches both show that proper drainage sometimes increases the growth considerably. Moreover, tamarack, when growing on high land—as it does occasionally—makes a growth which compares favorably with that of any other tree in the region. The tree is rather a poor seeder. The seed germinates in peat or on mineral soil.

White Cedar

The white cedar *(Thuja occidentalis)* ranges from the valley of the St. Lawrence to northern Minnesota and down the Appalachian Mountains to North Carolina.

It is one of those unfortunate trees which is forced out by its neighbors and forced to live in the swamps. There it is usually found in pure stands, sometimes very dense, but sometimes mixed with tamarack and black spruce. It escapes from the swamps in some places and mingles with the trees of the border areas, commonly balsam, white pine, yellow birch, etc., but is unable to keep a permanent hold on such situations.

The white cedar usually grows in swamps where the peat is comparatively shallow and fresh. It will do even better on moist loam soil, if there is not too much competition from other trees. It is said to require a neutral or lime soil.

The white cedar appears to be quite tolerant in the swamp and can grow in very dense stands, but on the higher ground it seems less tolerant and is unable to compete with its hardwood neighbors, or even with the white pine.

White cedar is very sensitive to water conditions in the soil, and responds readily to partial drainage. Its root system is flat and shallow.

This tree seeds very profusely, and the seeds germinate very well if soon planted, but they cannot be stored successfully. The seed is scattered by the wind and, in some cases where the trees are overhanging lakes or streams, is carried by water. It requires a seedbed of moist peat or duff. In sphagnum swamps it often reproduces by layering.

Its rate of growth is fairly rapid in well-drained places, and it occasionally lives to a very old age and attains great size, but as a rule the swamp tree is rather slow-growing and stunted. Practically all of the older ones are hollow-butted.

Like all the other swamp trees, it is especially susceptible to fire damage because of its shallow roots and its inflammable needles.